MEMOIRS

OF THE

GEOLOGICAL SURVEY

OF

GREAT BRITAIN

AND OF THE

MUSEUM OF PRACTICAL GEOLOGY.

THE

SOUTH STAFFORDSHIRE COAL-FIELD.

BY

J. BEETE JUKES, M.A. CAMB., F.R.S., &c.
LOCAL DIRECTOR OF THE GEOLOGICAL SURVEY OF IRELAND.

SECOND EDITION.

PUBLISHED BY ORDER OF THE LORDS COMMISSIONERS OF HER MAJESTY'S TREASURY.

LONDON:
PRINTED FOR HER MAJESTY'S STATIONERY OFFICE.
PUBLISHED BY
LONGMAN, GREEN, LONGMAN, AND ROBERTS.

1859.

NOTICE.

The Session of the Government School of Mines and of Science applied to the Arts commences early in October

Mining Mineralogy	Warington W. Smyth, M.A. F.R.S.

The Chemical Laboratory, under the direction of Dr. Hofmann, and the Metallurgical Laboratory, under the direction of Dr. Percy, are open for the instruction of Students.

A Prospectus and Information may be obtained on application to

Trenham Reeks, *Registrar.*

Jermyn Street, London, S.W.

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PRINTERS TO THE QUEEN'S MOST EXCELLENT MAJESTY.

NOTICE.

THE Memoir on the Geology of the South Staffordshire Coal-field, by Mr. J. Beete Jukes, having been long out of print, a second edition was much called for, and it gives me satisfaction to perceive that a work which has proved so useful to the mining proprietors of that district should have undergone material improvements by Mr. Jukes, who, having himself re-examined the tract, has availed himself of all the information afforded by new workings, &c.

The statistical note by Mr. R. Hunt on the amount of coal and iron raised in South Staffordshire has been brought up to the year 1858.

RODERICK I. MURCHISON,
Director-General.

Geological Survey Office,
Jermyn Street, London.

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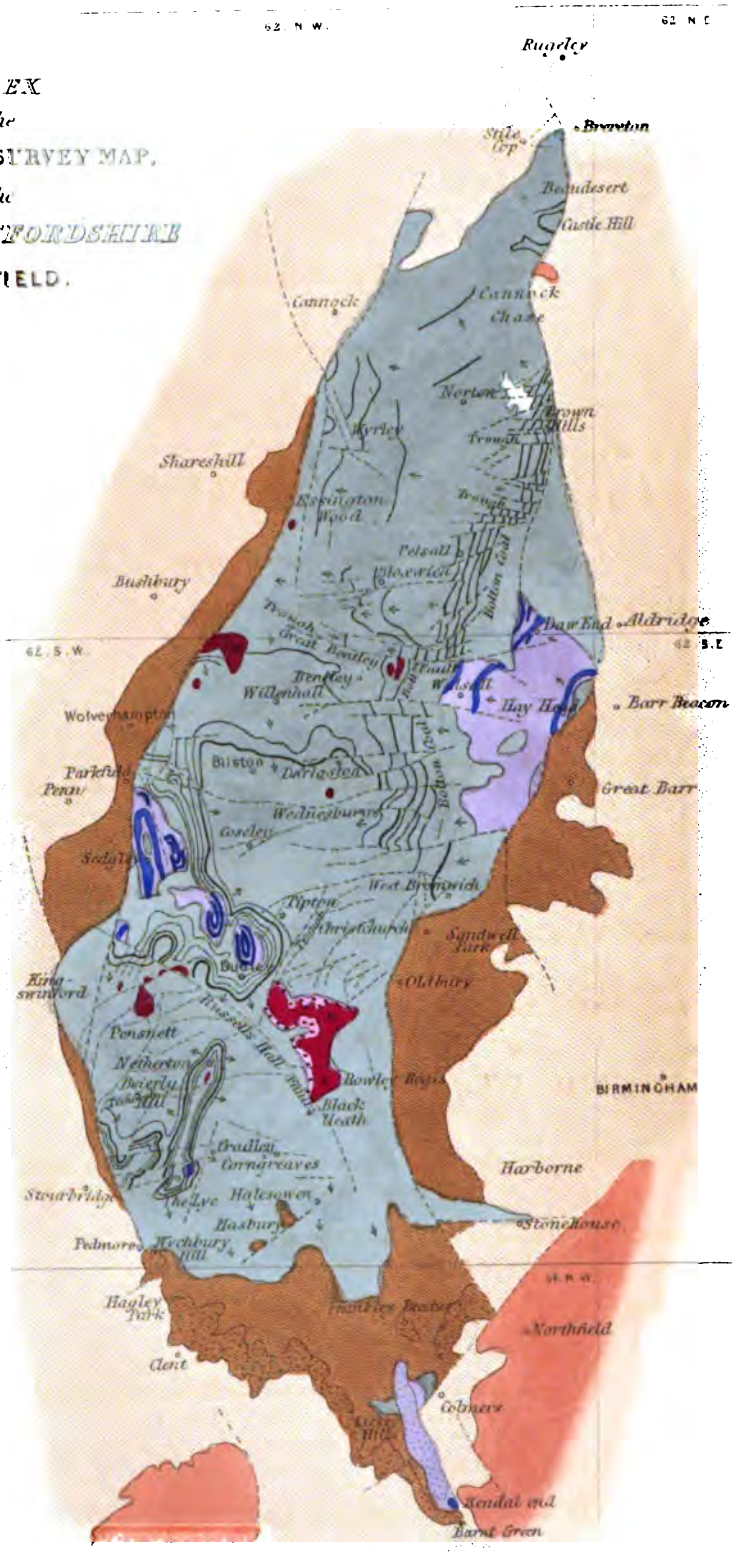
of the
SOUTH STAFFORDSHIRE
COAL FIELD.



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J.W. Lowry sc.

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— 62. N.W. N.E., S.W., and S.E. Quarter Sheets.
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These Maps and Sections are to be procured at the MUSEUM OF PRACTICAL GEOLOGY, Jermyn Street, London, or from Messrs. LONGMAN & Co., Paternoster Row, London.

PREFACE TO THE SECOND EDITION.

It was not till the month of October 1858 that I could make arrangements for such a re-examination of the South Staffordshire Coal-field as should enable me to bring out a second edition of this Memoir. Many new mines and cuttings of different kinds having been opened during the preceding nine years, this re-examination, brief as it was, afforded fresh information on some points that had previously been obscure.

My colleagues, Messrs. Hull and Howell, under the direction of Professor Ramsay, have completed the examination of the details of the New Red Sandstone of the Midland counties, and Professor Ramsay has now contributed (pp. 3 to 8) an account of their results.

I have added also to the description of the Permian rocks an abstract of Professor Ramsay's remarkable speculations on the origin of the large angular blocks in the Permian breccia (pp. 13 to 15).

In the coal-field, the new pits at Essington and those on Cannock Chase gave additional data for the co-relation of the Wyrley and Essington district with the remainder of the field. The identity of the separated coals of Wyrley and Essington, (from the Old Robins coal down to the Bentley Hay coal), with those which, in the central part of the coal-field, unite to produce the Thick coal, is thus put beyond doubt. There was, indeed, no doubt on my own mind of this fact even ten years ago. A diagram, illustrative of the method of this expansion of the measures and separation of the coals, is now added to the general description of the Coal-measures.

An important change has been made, both in the Memoir and in the latest edition of the maps and sections, as regards the

classification of certain red clays and sandstones which occur at Walsall Wood, Essington Wood, and at other localities about or within the coal-field. These were at first supposed to belong to the New Red Sandstone, afterwards were believed to be Permian, but are now decided to be true Coal-measures. I find in my own manuscript notes, made during the survey of the coal-field, the strongest expressions of opinion that these were in reality Coal-measures; but as that conclusion involved practical consequences which might, if erroneous, have led some persons into fruitless expenditure, it was thought safer to colour them as Permian until more evidence could be procured.

The opinion that they are upper Coal-measures, however, is now so strongly supported by my colleagues, and by several resident gentlemen of practical experience, and seems so far confirmed by the facts learnt in sinking the pits at Coppy Hall by the Rev. Baily Williams, that there is no longer any necessity for reserve in expressing the opinion, or for hesitation in altering the colouring of the maps and sections accordingly. It adds several square miles to the area of the northern part of the coal-field.

The driving of the tunnel beneath the Rowley Hills, which by a rather unfortunate misnomer is called the Netherton tunnel, added somewhat more of precision to our ideas respecting the "position and lie," of the Rowley basalt than we previously possessed. I regret that I was not aware till it was completed that this so-called Netherton tunnel was being driven through the base of the Rowley Hills, and thus was not led to visit it during the operation. This and the analyses of two specimens of the trap rocks by Mr. Henry, of London, has enabled me to give a little more complete account of the igneous rocks of the district. An equally good analysis of the "green rock" or "greenstone" of the district is still a desideratum.

I regret that an injustice was done in the first edition of this Memoir to the memory of Mr. Keir, whose excellent account of the coal-field, so far as it was known in his day, was published in Shaw's History of Staffordshire. Not only were his labours altogether ignored, but some of his materials were used at second hand without any acknowledgment of the true source whence they

were derived. I need hardly say that this injustice was unintentional, and arose from forgetfulness, chiefly the result of the circumstances under which the Memoir was composed. The documentary materials for it were collected from different persons at different times, and were reduced to order at intervals in different parts of England, Wales, and Ireland. Anything like research into books was almost necessarily precluded, and the attention was fixed on the materials which were at hand, and which could be carried about in the portmanteau.

This absence of research into the labours of previous or contemporaneous writers is a defect which it is difficult for those to avoid who are almost constantly engaged in field work and debarred from access to libraries, except at rare and short intervals. It has been indeed hitherto sufficiently difficult for the officers of the Geological Survey to find time to give any written account even of their own labours, the results of which have been chiefly published in the form of maps and sections.

In the following Memoir the attention is confined solely to the facts observed in the district; from some questions that have been put to me, however, I believe that a few preliminary words respecting the relation of the Carboniferous rocks of South Staffordshire to those of the neighbouring districts will not be out of place.

I have been asked especially as to the reason of the absence of the groups of rock known as Millstone grit, Carboniferous limestone, and Old Red sandstone, between the Coal-measures and the Upper Silurian rocks of South Staffordshire.

If we proceed from the South Staffordshire to the North Staffordshire coal-field, a distance of only 20 or 25 miles, we find a vast difference in the constitution of the Carboniferous rocks. In South Staffordshire the Carboniferous rocks consist of Coal-measures only, the maximum thickness of which does not seem ever to have much exceeded 1,000 feet. In North Staffordshire these beds are far more numerous, and attain an aggregate thickness four or five times greater. Thick masses of sandstone occur about their base, which are grouped together under the name of the Millstone grit. Below this, as we go towards Derbyshire, we find thick beds of black shale, in some places

interstratified with thin limestones, and from underneath these comes out an assemblage of beds of pure limestone several hundred feet in thickness, forming all the beautiful hill country that spreads from Dovedale to Matlock and thence to Castleton and Buxton. This group of limestone is called the Mountain or Carboniferous Limestone, and the black shale between it and the Millstone grit is known as the Upper Limestone Shale.

The Carboniferous Limestone, either simple as a group of beds of pure limestone or complicated by being more or less interstratified with shales and sandstones, extends from Derbyshire to the borders of Scotland with a mean thickness of probably 2,000 feet at least; it re-appears as a simple limestone in North Wales, in Flintshire, and Denbighshire, and in the same form in South Wales and the adjacent parts of England, varying in thickness from 500 to 1,000 feet. The Coal-measures of the South Welsh coal-field are certainly 7,000 feet, even if they are not in some places 12,000 feet, in aggregate thickness, and have a thick group of sandstone beds at the base, which may be called the Millstone Grit, as well as another higher up, known as Pennant Grit. But from underneath the Carboniferous Limestone, which forms the thick enamelled lining, as it were, of the basins of the South Welsh and Forest of Dean coal-fields, there rises on all sides a great group of red and brown sandstones and red marls, known as the Old Red Sandstone. This Old Red Sandstone forms whole mountains of 2,700 feet in altitude (as the Vans of Brecon), and cannot in some places have a less aggregate thickness than about 10,000 feet.

Now these vast formations of Old Red Sandstone and Carboniferous limestone (to say nothing of the lower part of the Coal-measure series or Millstone grit) are altogether absent in South Staffordshire, neither is there the slightest reason for supposing that any part of them ever existed in that district. For not only are they absent in South Staffordshire, but there is a band of country running E. and W. across England from Leicestershire, through Warwickshire, South Staffordshire, North Shropshire, into Montgomeryshire, along which they are equally deficient.

In Leicestershire, the Carboniferous limestone, thinning out

from Derbyshire, ends on the north side of Charnwood Forest, while the Coal-measures overlap it and rest upon the Cambrian rocks. In Warwickshire no Carboniferous limestone makes its appearance. In South Staffordshire the Coal-measures rest directly upon Upper Silurian rocks. In the Coalbrookdale coal-field the Coal-measures resting towards the south on the Old Red Sandstone, overlap its termination towards the north, and repose upon Upper Silurian rocks, and further west, towards Church Stretton and the Breiddens, upon Lower Silurian and Cambrian rocks. Thin scraps of Carboniferous limestone, indeed, show themselves about Lillieshall, as if spreading just so far from Derbyshire, and also at the Clee Hills, as if dying out from South Wales, and the Old Red Sandstone likewise stretches from the latter direction, but thins out and terminates before reaching the Severn. It is clear then that the absence of the Old Red Sandstone and Carboniferous limestone from the narrow band of country before indicated, is due to causes operating during the deposition of those formations. They each died away and terminated as they approached it both from the north and the south.

Now these formations were deposited under water, the Carboniferous limestone certainly under the sea, as is shown by its being almost entirely made up of the remains of marine animals, it seems natural then to suppose that the area towards which they thus both thin out and terminate was not under water, but formed dry land. It is, in fact, almost certain, that whilst the sea flowed deep over the remainder of that space where England and Wales now exist, during the periods when the great formations of Old Red Sandstone and Carboniferous limestone were in course of deposition, a narrow promontory, or an island, or a group of closely connected islands ran in an east and west line across the district before pointed out. This land, however, must itself have been depressed either wholly or in part while the Coal-measures were being deposited, and as it slowly sank beneath the water, sheet after sheet of Coal-meausres extended over it, till, perhaps, the whole neighbourhood was finally buried under one wide-spread subaqueous Coal-measure plain. Since that time it has not only been lifted up again, but broken, dislocated, and contorted by forces of dis-

turbance acting from below, and worn and eroded by denuding agencies acting from above; fresh formations have been deposited over it, and these also with the subjacent rocks broken and again denuded, till all likeness of its former state has been utterly destroyed, and its former condition left to be guessed at solely by deductions drawn from the relations which can be traced between the formations of which it is composed.

J. BEETE JUKES.

51, Stephen's Green, Dublin,
6th September 1859.

ON THE GEOLOGY OF THE SOUTH STAFFORDSHIRE COAL-FIELD.

By J. BEETE JUKES, M.A. Camb., F.R.S., &c.

LOCAL DIRECTOR OF THE GEOLOGICAL SURVEY OF IRELAND.

CHAPTER I.

Physical Geography of the District.

The district to be described in the following pages is situated chiefly in the southern division of the county of Stafford, but extends into part of the northern division of that county, as well as into the adjacent counties of Worcester,* Warwick, and Salop.

The most important portion of the district is the coal-field, which would be included within a line drawn from Brereton near Rugeley, through Cannock to Wolverhampton, thence through Kingswinford to Stourbridge, and from that to the hills known as the Bromsgrove Lickey, and thence by Harborne near Birmingham, through Aldridge, back again to Brereton.

The distance north and south from Brereton to the south end of the Bromsgrove Lickey is about 26 miles, that measured east and west from Wolverhampton to Barr Beacon, near Aldridge, is about nine miles.

The tract of ground included within the above-mentioned boundary is for the most part a gently undulating plain, having a mean height of about 400 or 500 feet above the sea. The low level part of the old Birmingham canal, extending from Birmingham to the locks near West Bromwich, is said to be 464 feet above the low-water mark at the docks of Liverpool, the high level part of the canal from the locks to Wolverhampton being 484 feet above the same datum. Numerous branches from this high level part are carried without a lock over the greater part of the central portion of the coal-field, from which near Walsall three or four locks lead up to the still higher branches over the northern part of it, while to the S.W., as we approach Wordesley and Stourbridge, numerous locks take the water down to the level of the river Stour.

There rise from this plain several hills and ridges of higher land, of which the following are the principal:—

1. The ridge of Bromsgrove Lickey, of which the highest point is said to be upwards of 900 feet above the sea.

2. The group of the Clent Hills, of which the highest point is about 950 feet above the sea.

* Dudley is in a detached part of Worcestershire, and Halesowen in a detached part of Shropshire, and little isolated fragments of the three or four counties are, in some places south of Dudley, so intermingled with each other, that it is often impossible to learn from the Ordnance map which county any particular spot may be in.

3. The group of the Rowley Hills, of which the highest is about 820 feet above the sea.

4. The ridge of high ground running from Dudley to Sedgley, of which the most conspicuous points are Dudley Castle Hill, 730 feet; the Wren's Nest, 730 feet; and Sedgley Beacon, 760 feet, above the sea.

5. The high ground about Barr, of which Barr Beacon is the summit, being about 800 feet above the sea.

6. The high swelling plateau of Cannock Chase, the highest point of which, Castle Hill in Beaudesert Old Park, is 900 feet above the sea.*

As the district forms part of the water-shed of England, it can, of course, have no navigable rivers; and its streams are few and unimportant. The high ground that runs from Frankley Beeches to the Clent Hills, gives rise, on the one side, to the little river Stour, running by Halesowen and Stourbridge, to Stourport, where it joins the Severn, and with it flows into the Bristol Channel; while on the other side are the sources of the little river Rea, that flows through Birmingham into the Tame, and thence into the Trent and the German Ocean.

From Frankley Beeches, the water-shed runs through Rowley, Dudley, and Sedgley, to Wolverhampton. On the west of that ridge the streams run either directly into the Stour, or into the Smester Brook, which, rising just west of Wolverhampton, runs nearly due south to join the Stour near Stourbridge. On the east of the ridge, lying between it and the high ground of Barr Beacon, is the basin of the Tame river; the sources of this river are near Bloxwich, whence it runs south and south-east to Aston near Birmingham, and after receiving the Rea, sweeps off northward to Tamworth, in order to join the Trent. In the northern part of the district, the drainage runs entirely into the Trent, the eastern brooks running directly into that river, the western streams flowing first into the Penk, which after joining the Sow near Stafford flows into the Trent at Great Haywood.

The river Trent, coming from the N.N.W. to this spot, bounds the district on the N.E., cutting it off by a very well marked and sudden depression; the mean height of the Trent valley here being not more than 250 feet above the sea.

CHAPTER II.

Description of the Rocks.

The rocks, or geological formations, entering into the structure of this district are—

Secondary, or Mesozoic Formations.	1. The Lias.
	2. The New Red Sandstone.

* These heights are only approximate; but they are believed to be within 20 or 30 feet of the truth.

Primary, or Palæozoic Formations.	3. The Lower Red Sandstone, or Permian. 4. The Coal-Measures. 5. The Silurian Rocks.
Igneous, or Unstratified Rocks.	Basalt and Greenstone.

1. *The Lias.*

Although not strictly lying within the district, I mention this formation because its existence in Staffordshire was first discovered during the survey of the coal-field, and because it may have a rather important bearing on some of the theoretical results arrived at. It occurs on the high ground of Needwood forest. It consists of alternations of blue shale and limestone, the bands of limestone being not more than 6 or 8 inches in thickness, over which are some arenaceous beds becoming in the upper part a white shaly sandstone. The limestone bands have not yet been worked, but they would probably have the same hydraulic character as those of Barrow-upon-Soar.* My colleague Mr. Howell, however, who mapped this neighbourhood, informs me that the limestone here is more argillaceous, and not so pure as the Lias limestone of other places, that near Stratford-on-Avon for instance. In the sandy beds are some imperfect casts of bivalve shells.

CHAPTER III.

DESCRIPTION OF THE ROCKS—*continued.*

2. *The New Red Sandstone.*

SINCE the publication of the first edition of this Memoir, the New red sandstone of the midland counties has been thoroughly surveyed, and its several parts analysed much more completely than before.

This has been done chiefly by the labours of Messrs. E. Hull and H. H. Howell, under the direction of Professor Ramsay, who now supplies the following abstract of the results which have been arrived at, in the passages included within inverted commas.

"The New red sandstone around the South Staffordshire coal-field consists of the following subdivisions:—

		Maximum Thickness. Feet.
Keuper beds.	Red Marl - - - -	600
	White and Brown Sandstone with beds of Red Marl. Waterstones -	300
Bunter beds.	Upper Red and Mottled Sandstone -	500
	Conglomerate or Pebble beds -	500
	Lower Red and Mottled Sandstone -	200

* My attention was directed to this Lias district by my friend Mr. T. Turnor, of Abbotts Bromley, who had himself a suspicion of its true character from the observations of his friend Mr. E. Pickering.

"The division of the Bunter beds into three sub-formations was first made out by Mr. Hull while mapping the New red sandstone near Coalbrook Dale, and I considered it so important that, with the approval of the late Sir Henry De la Beche, I instructed the members of the Survey engaged on the New red sandstone to map all the subdivisions, more especially as in doing so we had a means of detecting a number of the faults that traverse the country.* This accordingly has been done from the south end of the Malvern hills to Lancashire and Nottinghamshire, and the sub-formations have been found always to maintain the same order of superposition, although occasionally one or more members may be absent. In general they are easily distinguishable from each other, except when the Upper and Lower Red and Mottled sandstones chance to be brought together by faults. All of them occur in the district described in this Memoir."

KEUPER.—*The Red Marls.*—This subdivision is principally composed of marl of a dull red colour, with occasional thin bluish shaly beds, containing sometimes small layers of bluish-white sandstone a few inches thick. In the bottom part of the marls occur local beds of sandstone some feet in thickness, sometimes brown, sometimes yellow or white, containing few or no pebbles, generally rather shaly, and not often marked by oblique lamination. The marls are likewise generally shaly, and are sometimes slightly arenaceous, especially in the lower beds. Like all marls, they, when dry, frequently crumble into small cuboidal fragments.

In Staffordshire neither the gypsum nor the salt of this sub-formation is very abundant. Beds of gypsum may be seen cropping to the surface in several places about Tutbury and Uttoxeter, and the substance is met with elsewhere in wells and pits. The salt is only known by the occurrence of brine springs, which are met with at two places, one at Silkmoor, 1½ mile south of Stafford, the other at Shirley Wych, near Weston-upon-Trent. At the latter place there is a shaft sunk to the depth of 414 feet, of which Mr. Hull procured the following section:—

	FT.
Drift sand and gravel - - - -	54
Gypsum - - - - -	6
Red marl - - - - -	354
	414

It is probable, therefore, that the total thickness of this sub-formation cannot be much less than 600 feet.

Waterstones.—"At the base the Red marl passes into or rather alternates with beds of white and brown sandstone, formerly considered the uppermost part of the Bunter beds, but now placed by the survey as the lowest member of the Keuper series, and called the Lower Keuper sandstone or Waterstones. These strata are the

* This may some day throw much light on the mode of working the coal below, should it ever be searched for and found.

equivalents of the sandstones of the Peckforton hills and of Warwick, which contain Labyrinthodon remains, and in the district surrounding the South Staffordshire Coal-field fossil plants were found in them near Bromsgrove, and a small ganoid homocerque fish, described by Sir Philip Egerton under the name of *Dipteronotus cyphis*.

"Frequently the beds are rippled or current marked, and also traversed by sun cracks, showing that some of them were alternately covered by water and exposed to the air.

"This subdivision occurs in great force round Bromsgrove and in the country between Ombersley and Stourbridge. It lies in the form of a synclinal curve, widening to the south, where it is overlaid by a broad tract of red marl. The sandstone series is here probably from 200 to 300 feet thick. It also occurs on Penn Hill and Oreton Hill as a faulted outlier, and further north it ranges from Whitwick to Penkridge, expanding in places to a width of several miles. Its base partly consists of calcareous breccia and conglomerate, and its greatest thickness is probably about 300 feet.

"On the east of the Coal-field equivalent strata of the same general type (occasionally interrupted by faults) run from the Caradoc sandstone of the Lickey Hills, by Birmingham, to the north of Sutton Coldfield, and from the border of the Coal-field at Cannock Chase to the Trent near Lichfield.

"BUNTER.—*The Upper Red and Mottled Sandstone.*—The Upper Red and Mottled sandstone round the South Staffordshire Coal-field invariably succeeds, in descending order, the strata described above. It varies in thickness from 400 to 500 feet, and generally consists of fine bright red sand, sometimes streaked and mottled with yellow. These sands are often false bedded, but they never contain pebbles. On the east side of the Coal-field this sub-formation ranges from the neighbourhood of Harborne by Birmingham to Sutton Coldfield, and again from the southern part of Cannock Chase eastward to Shenstone. On the west the beds strike in a narrow strip from the Birmingham and Gloucester railway to Hagley, and elsewhere, interruptedly and broken by faults, from the neighbourhood of Stone in Worcestershire to Tettenhall near Wolverhampton. A patch about 5 miles in length also occurs west of Cannock, between Cross Green and Manstey Wood. Good sections may be seen in a cutting of the Birmingham and Gloucester railway, south of Blackwell station, in the new cemetery at Birmingham, in the road cuttings about Tettenhall and Compton near Wolverhampton and at other places marked by arrows on the map.

"*The Conglomerates or Pebble Beds.*—The pebble or conglomerate beds lie below the Upper Red and Mottled sandstone. They vary in thickness from 300 to 500 feet, and in our district are probably thickest south of the Lickey Hills and in Cannock Chase, north of Cannock. They range from a fault near Blackwell station south of the Lickey, to Hagley, lying here directly on the Permian strata, without the intervention of the Lower

Red and Mottled sandstone. West and north of Hagley the same strata, repeated by faults, run from the neighbourhood of Church Hill and Heathside to Wolverhampton and the country west of Trysull, and beyond Wolverhampton they strike northward to Cannock in a band on an average about a mile wide. North of Cannock they widen out, and form almost all Cannock Chase between Rugeley and Bednall. On the east the chief area lies between Harborne, Sutton Park and the Brown Hills, where the New red sandstone is faulted against the Coal-measures.

"The conglomerate is generally more or less incoherent, but occasionally it is cemented into hardish rock by the presence of carbonate of lime. In general, however, it still so completely retains its original character of gravel, that it may be dug out with the pickaxe and shovel, and is used for gravel pits. Occasionally it consists chiefly of sand, with only a few scattered quartz pebbles, as, for instance, in the small patch between Northfield and Frankly.

"The pebbles found in these conglomerates consist chiefly of brown and liver-coloured quartz rock, well water-worn and rounded. These were for long considered to have been derived from the waste of the altered Caradoc sandstone of the Lickey Hills; but when we consider that the same conglomeritic formation, only interrupted by faults, extends all the way from the neighbourhood of Stourport to Lancashire and Nottinghamshire (wherever it has been mapped by the Geological Survey), it is evident that the pebbles have been derived from some other source, the locality of which is unknown. Besides these, there are other occasional pebbles of white quartz, coal-measure sandstone, or millstone grit (stigmaria markings being sometimes discernible in them), chert containing casts of crinoidal stems from the mountain limestone, dull red sandstone, traps, agates more or less decomposed, altered slate, and jasper."

The Drift gravel that more or less covers the country is in a great measure derived from the waste of this conglomerate, and without practice it is at first, sometimes, very difficult to distinguish between these ancient gravels of the New red sandstone period and the other gravels that belong to the much more modern period in which "the Drift" was formed.

In examining a gravel pit for this purpose, the first thing to look for is a chalk flint. True chalk flints, with chalk fossils, may be in some places pretty abundantly found in the gravels of Staffordshire, as sometimes also oolitic and liassic fossils.* Where these occur they are, of course, conclusive evidence against the gravel being of the New red sandstone period. Very often, however, there are large deposits of gravel belonging to the Pleistocene or some of the more recent periods, in which no fragments of rock are found that can be identified with anything newer than the Coal-measures. Still, even these may, after a little practice, be

* Gryphæa incurva and large fragments of ammonites and other fossils are sometimes found in great abundance in patches of red clay, belonging to the Drift deposits, near Wolverhampton and other places.

distinguished from the New red (or Triassic) gravels, by their more irregular heaped-up method of deposition; by the sand in which the pebbles lie being of a paler and yellower colour than that of the New red; by the pebbles lying edgeways and confusedly, instead of horizontally and more or less regularly stratified; by the pebbles being often dirty, while those of the New red are generally quite clean (a remark of Mr. Hull's), and by a vague but sufficiently appreciable *facies*, which is not describable, but can be learnt by a little practice, and by that alone.

Figures 1 and 2 represent two modes of occurrence of the conglomerates in the New red sandstone.

Fig 1.

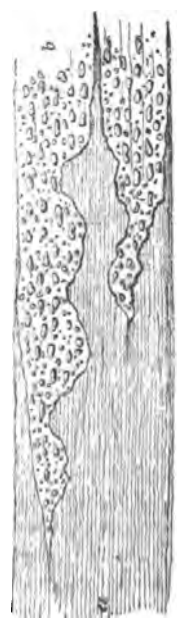
Road cutting near Wordesley, 2 miles north of Stourbridge.

Scale, 1 inch = 40 feet.

a. Brick-red sandstone.
b. Bands of red marl.
c. Conglomerate, gravel of New Red period.
d. Debris, &c., gravel of the Drift period.

Fig 2.

Canal cutting near Brown Hills, Cannock Chase.



Scale, 1 inch = 10 feet.

a. Fine brick-red sandstone. *b*. Conglomerate, gravel of the New Red period.

"*The Lower Soft Red and Mottled Sandstone.*—The Lower soft red and mottled sandstone, when the section is complete, invariably comes between the pebble beds and the Permian or Coal-measure strata of our area. It is in general a bright red soft sandstone, occasionally streaked with yellow and white, and in most points strongly resembles the Upper soft red sandstone. It is, however, generally coarser and exhibits more false bedding. It is quite destitute of pebbles. Between the south end of the Lickey Hill and Hagley it is absent, the Pebble beds resting directly upon the Permian breccias; and the same is the case on the north and east of the Coal-field. West of Stourbridge it underlies the pebble beds in a narrow strip dipping east, and nearly 5 miles long, being faulted on the west against the Upper soft red sandstone. Still further west, repeated by this fault, it runs north from Kinfare by Spittlebrook Mill.

"On the east side of the Coal-field it is entirely absent, the Pebble beds resting directly on the Permian strata. Its thickness is very variable, and probably within the limits of the map described it never exceeds from 100 to 200 feet, but further west, in parts of Shropshire, it is very much thicker."

A. C. R. & J. B. J.

CHAPTER IV.

Description of the Rocks—*continued.*

3. *The Permian Rocks, or Lower Red Sandstone.*

If the survey had been confined to the immediate neighbourhood of the South Staffordshire coal-field it would have been impossible to have obtained sufficient evidence for establishing a boundary between the New red and the Lower red sandstone. In North Staffordshire, however, better sections exist, and my colleague, Mr. Hull, in examining that district, was enabled to acquire a knowledge of the characteristic distinctions of the two formations, which he afterwards brought to bear on the examination of our district. Professor Ramsay having visited North Staffordshire with Mr. Hull, afterwards went over part of the South Staffordshire district with Mr. Hull and myself. The description of this formation, therefore, must be taken as the result of our joint labours.

It is as well to premise that the lithological distinctions between the rocks of this formation and those of the New red sandstone are often rather vague and sometimes but small. This is more especially true with respect to the second or Waterstone subdivision of the New red sandstone, the dark brown or pale red sandstones of which, with their interstratified marls and calcareous bands, are scarcely distinguishable by any lithological characters from similar

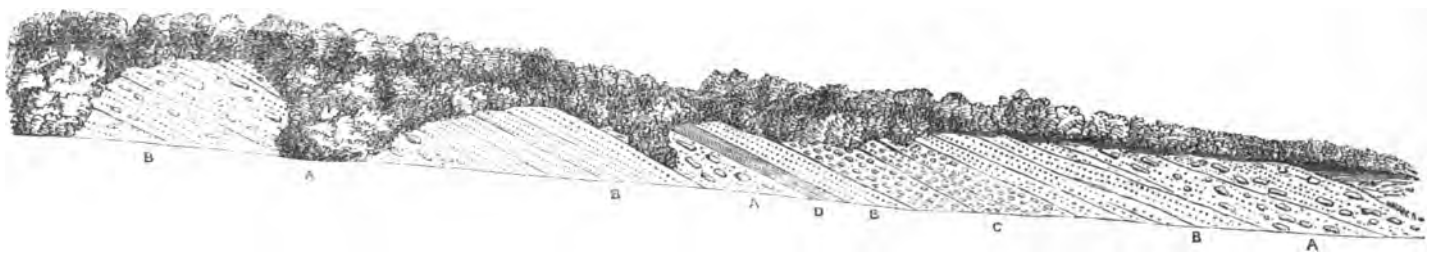
beds in the Permian formation. There are, however, we believe, no brick-red sandstones like that of the Bunter, and scarcely any quartzose conglomerate to be found in the Permian formation; whenever, therefore, we get the above-named doubtful beds in our district, we can determine their geological horizon simply by their place with regard to the soft red and mottled sandstones and quartzose conglomerates. There are two parts of the district from the examination of which it is possible to arrive at a tolerably complete notion of the structure and sequence of the Permian rocks, namely, the country about the Lickey and Clent Hills, and the neighbourhood of West Bromwich.

The country about the Lickey and Clent Hills.—The south end of the Lickey Hill, that on which the obelisk stands, is composed of the quartzose conglomerates and red sandstone, believed to be there the base of the New red. On the northern end of the Lickey, about Square Coppice, as also on all the summits of the high ground of Segban, Romsley, Frankley Beeches, and the higher parts of the Clent Hills, where we get what appear to be the highest of the Permian beds in their respective localities, we find these beds to consist of a remarkable trappean breccia. This breccia is principally made up of angular fragments of trappean rocks, but almost equally angular fragments of many other rocks are found in it. A good section of this trappean breccia is shown in a road cutting just north of the brook in the lane leading from the Bell Inn, at Northfield, to Bangham Pit. The matrix of the breccia is here a brown sandstone, in places calcareous, interstratified with thin bands of marl. The imbedded fragments, some of which are slightly rounded, but the majority remarkably angular, vary in size from mere grains to blocks a foot or a foot and a half in diameter; they consist of porphyritic trap in many varieties (but no basalt or greenstone) of sandstone of various kinds, of quartz-rock, and of Silurian limestone and sandstone, some of which is certainly Llandovery sandstone, not at all altered. There are slabs of these Silurian limestones and sandstones at least 1 foot to 1½ foot square and 5 or 6 inches thick, with their edges scarcely at all rounded. The whole mass has a well-stratified character, and in some places is firmly compacted together by carbonate of lime, but in others is more or less incoherent. The slabs of Llandovery sandstone are now easily split into thinner flags by a very slight blow, and some of them seem to be already so separated in the ground. This, together with their angular character, inclines me to believe that they have not travelled many yards from their original site, and that a boss, or peak, or ridge of the Silurian sandstone lies concealed under the Permian rocks somewhere close by.

The following rough sketch (see Fig. 3), drawn to scale with a measuring tape, will give an idea of the mode of occurrence of these breccias as seen in the bank of the lane above spoken of.

Fig. 3.

Diagrammatic sketch of the Permian sandstone and breccia in the bank of the lane leading from the Bell Inn, Northfield, to Bangham pit. Length of sketch about 80 yards.



A. Coarse sandstone and conglomerate, containing large angular blocks and slabs of shelly sandstone, from 16 to 18 inches long, and 4 to 6 inches thick.

B. Fine sandstone, sometimes containing pebbles and smaller angular fragments.

C. Hard, very regularly stratified breccia of flat angular fragments.

D. Bed of red or brown marl.

In the Clent Hills the breccia has a red marly base, and is chiefly made up of large and small angular fragments of a dull red felstone porphyry, often much decomposed, and splitting, when struck with the hammer, along concealed joints, so as to expose no fresh fracture; of fragments of greenstone; of one or two kinds of sandstone; "with several fragments of a porcelanic-looking slaty rock, like some of those west of the Stiperstones. Near St. Kenelm's chapel this breccia passes down into 1, red marl, with small brecciated fragments at the top; 2, red standstone; 3, red marl; 4, calcareous sandy rock."*

On Romsley Hill, going down into Hunnington, just below the trappean breccia, was found a dull brown sandstone, with a band of calcareous concretionary sandstone. Near a place called Newtown, about a mile to the east of that, are quarries where a similar concretionary calcareous sandstone (a regular cornstone) has even recently been burnt for lime. In going down the brooks from this point to Twylands and Cooks Woods, we get numerous alternations of brown, or brownish grey, or purple, or pale salmon-coloured sandstones, sometimes thick-bedded, sometimes flaggy, with beds of marl, either dark purple with light-coloured spots or blood-red. Many of the sandstones are calcareous and concretionary, and might be mistaken for some of the cornstones of the Old red. A dark purple sandstone, with minute white specks, is a characteristic bed. All these beds are apparently horizontal, being successively exposed only by the rapid fall of the ground; and near the bottom of the slope the blueish grey sandstones and shales of the coal-measures appear from underneath them, likewise in a horizontal position.

The neighbourhood of West Bromwich.—In the cutting of the Birmingham and Dudley railway, south of Sandwell Park, were seen rising to the west, from under a thick mass of quartzose conglomerate, a series of brown and pale sandstones, with merely a few small and slightly angular pebbles. In these beds are masses, believed to be *in situ*, of a singular calcareous conglomerate that is better shown in other places. Under them, we have other pale sandstones alternating with bright red marls, all rising to the westward at an angle of about 10°. We have an account of a boring made hereabouts near "The Ruck of Stones," some years ago, by Mr. J. W. Unett (see Vertical Sections, sheet 18, No. 27), consisting entirely of alternations of red, brown, and grey sandstones of various degrees of hardness, with many beds of red marl, mottled clunch, and other similar materials, all evidently belonging to the formation we are now describing. The depth of the boring was 221 yards 1 foot, or 664 feet.

Nearly a mile west of this, and therefore commencing in much lower beds than are seen in the railway cutting, we have several deep coal pits, the most remarkable of which are those formerly sunk by Messrs. Davis at Bullocks farm, near Spon-lane (see Vertical Sections, sheet 18, No. 28). In these pits they passed

* Professor Ramsay's MS. Notes.

through a mass of sandstones and marls belonging to this formation, 262 yards 2 feet, or 728 feet thick, or, deducting the odd 28 feet for surface drift, &c., 700 feet of Permian, a good part of which at all events, if not the whole, must be below the 660 feet passed through at the "Ruck of Stones." What makes the section of these pits most remarkable, however, is that there occurred in them a small seam of *true Permian coal.* The following is an abstract of the upper part of the section :—

	FT.	IN.
1. Sand, &c. - - - - -	28	6
2. Alternations of red sandstone with red and mottled marls and clays - - - -	169	0
3. Fire-clay - - - - -	3	0
4. White binds - - - - -	12	0
5. Little coal - - - - -	0	10
6. Fire-clay - - - - -	3	8
7. Red clay and sandstone - - - -	28	0
8. Dark and pale red sandstones - - -	213	6
9. Alternations of red and white sandstone, with red and mottled clays and marls - - -	270	0
	727	6

I saw masses of the fire-clays Nos. 3 and 6 on the pit bank while these pits were being sunk, and they did not differ either in colour or in any mineral character from the fire-clays of the coal-measures, except in having small calcareous nodules interspersed through them. These nodules were carefully searched for fossils, but none were discovered. In the red sandstones below, however, numerous rough casts of the large stems of plants, something like rude *sigillariæ* occurred.* Part of the 10-inch coal was shaly and rotten, but about two inches of it is a beautifully bright coal, highly bituminous, very brittle, with curious circular concentric concretionary markings.

At Lord Dartmouth's pits at West Bromwich Heath, there appears to be 268 yards 2 feet, or 806 feet of Permian rocks, alternations of red sandstone and marl, but without any grey fire-clay and coal. At the Lyng colliery there was 550 feet, at the Lewisham pits 315 feet, and at the Terrace pits, close to the fault, they had 135 feet of "red rock" (see Horizontal Sections, sheet 25, No. 7).

It appears, then, that there must be in the neighbourhood of West Bromwich a total thickness of 1,500 feet at the very least, composed of the rocks of this formation.

I have yet to describe the calcareous conglomerate mentioned above. This is well shown at Barnford Hill, two miles south of Oldbury, and thence to Brand Hall. It is composed almost

* These large stems of plants, as also the pale sandstone in which they lay, were exactly similar to those got by Professor Sedgwick from the Lower red sandstone under the Magnesian limestone in the county of Durham, specimens of which are in the Woodwardian Museum at Cambridge.

entirely of rounded and semi-rounded fragments of mountain limestone and chert, with some pebbles of sandstone that may be millstone grit. It is about 20 feet thick, and is in several places quarried and the limestone pebbles burnt for lime. It occurs again in a field opposite the Gough's Arms, at Great Barr, as also in Baggeridge woods on the west side of the coal-field.

Besides this calcareous conglomerate, many of the sandstones sank through in the pits, or exposed in the quarries and cuttings, are very calcareous, like those before described in the district south of the coal-fields.

The reader must be pleased to bear in mind, that these descriptions of the Permian and New red sandstone rocks are meant to apply solely to the district of the South Staffordshire coal-field and its immediate neighbourhood. The Permian rocks of the neighbourhood are believed to be variable, both in lithological character and in thickness, with perhaps many frequently recurring characteristics, but no uniformity. The thickness of the formation is believed to vary almost indefinitely within the limits of 1,000 or 3,000 feet.

Professor Ramsay, in his paper on the Permian breccias in the Geological Journal,* gives a more full and complete account of them than is contained in the above brief observations, and takes a different view as to their origin. He first of all describes those about Enville, where the Permian rocks are largely developed. The breccias there consists of "angular or sub-angular" fragments, "with "flattened sides and but slightly rounded edges," embedded in "a deep red hardened marly paste. The pieces collected consist "chiefly of fragments of micaceous schist, micaceous sandstone, "quartz rock, grey sandstone, chert, purple grit, green sandy slate "(one of them polished and scratched), black slate, altered slate, "greenstone, felstone, felspathic ash, and reddish syenite. The "last is doubtful. A nodule of ironstone was also observed, and "a few quartz pebbles. None of them are larger than 6 or 8 "inches in diameter."

He then describes the breccia of the Clent Hills in the following terms:—

"The breccia here consists of pieces of various rock embedded in a hardened red marly paste. Like those near Enville, they are generally angular, or have their edges but slightly rounded. Their sides are often flattened, sometimes polished, and occasionally scratched. They rarely exceed a foot in diameter. On Clent Hill the fragments consist of felstone porphyry, greenstone porphyry, greenstone amygdaloid, ribboned slate, black and green slate, red sandstone, quartz conglomerate, and felspathic ash. In a section near Romsley stones of the same nature were found, including altered sandstone, conglomeritic ash,

* On the occurrence of angular, sub-angular, polished, and striated fragments and boulders in the Permian breccia of Shropshire, Worcestershire, &c., and on the probable existence of glaciers and icebergs in the Permian epoch, by Andrew C. Ramsay, F.R.S., F.G.S., Geol. Journal, vol. ii. p. 185.

banded felspathic ash, quartz rock, variegated marl, quartz pebbles, altered slate, ribboned slate, and blocks of a coarse conglomerate.

"The igneous rocks of Staffordshire are very different from those in the breccia; and none of the other kinds quoted occur in that district, with the exception, perhaps, of the quartz rock, which might be compared to that of the Lickey."

Professor Ramsay then goes on to show reasons why even the quartz rock fragments are not derived from the Lickey, but as the facts mentioned by him will, in my opinion, admit of a rather different interpretation to that which he gives them, I proceed to his description of the breccia near Northfield.

"The summit of the hill, called Frankley Beeches, is crowned by an outlier of the breccia; and it also forms a piece of ground about a mile and a half long, a little to the north-west of Northfield, a good section* of which occurs in the lane leading from Northfield to Bangham pit. The larger stones lie mostly at the top. Many of them consist of Caradoc limestone (Upper Caradoc† of some geologists), and calcareous sandstone and conglomerate, some of them attaining a diameter of about two feet. I submitted a collection of the fossiliferous pieces to Mr. Salter, who determined the following species:—

"*Strophomena compressa.*
Orthis calligramma.
Atrypa reticularis (very common).
Spirifera trapezoidalis.
Leptæna (*Strophomena*) *depressa.*
L. transversalis.
Rhynchonella semisulcata.
Pentamerus oblongus (rare and small).
P. undatus.
P. lens.
Mytilus mytilimeris.
Encrinurus punctatus.
Favosites alveolaris.
Petraia bina.
P. subduplicata.
Heliolites interstinctus.
Scalites (*Raphistoma*) *lenticularis.*
Euomphalus funatus (var. *sculptus*).
Goniophora cymbæformis.
Serpulites.

"Besides the blocks containing these fossils, the breccia includes fragments of other calcareous sandstone, ribboned slate like that near Shelve, quartz rock, porphyritic felspathic ash, felstone and greenstone like that of the Lower Silurian rocks, purple conglomerates similar to those of the Longmynd, and yellow sandstone and black chert, the latter like that of the Carboniferous limestone.

"The Upper Caradoc (Llandovery) limestone and fragments of calcareous sandstone and conglomerate are peculiar. They do not resemble the Caradoc beds of Walsall, Builth, Malvern, Mayhill, or the Lickey; but both lithologically and zoologically they are like the equivalent strata that rest unconformably on and once formed the

* This is the section drawn in Figure No. 3.
† Now called Llandovery sandstone.

beaches surrounding the Longmynd and adjacent Lower Silurian rocks, where *in situ* they contain green and purple slaty fragments and pieces of felspathic trap, derived from the waste of that ancient Cambrian and Lower Silurian island. They may be identified by this circumstance, for in no other place with which we are acquainted does the Upper Caradoc assume this character; and Mr. Salter also gives the confirmatory opinion that the assemblage of fossils nearly resembles some of the groupings in the present rocks near Hope. It is, therefore, difficult to escape from the conclusion that the rocks generally must have travelled from that country across a space of from forty to fifty miles."

As I had no personal acquaintance with the Llandovery rocks on the flanks of the Longmynd, near Church Stretton, I failed to recognize the fragments of slate and other rocks which were found by my friend and colleague in the pieces near Northfield until I saw his collection in Jermyn Street, and many of the pieces certainly appeared to me, as before stated, very like the sandstones near Barr, and the pieces which were formerly to be seen lying on the old pit banks north of the Colmers near the Lickey.

Professor Ramsay then describes other localities where this Permian breccia appears, between the Forest of Wyre and the south end of the Malvern Hills. One of these localities, called Church Hill, nearly half way between Stourport and the Titterstone Clee Hill, is very remarkable, since it forms an outlier of the breccia resting upon and entirely surrounded by Coal-measures. Professor Ramsay shows that these breccias extend altogether over an area of not less than 500 square miles,* and points to the fact that the great majority of the angular fragments seem to be all derived from the neighbourhood of the Longmynd near Church Stretton.

He arrives at the conclusion, from this great extension of the breccia, from the size (up to three-quarters of a ton) and angularity of the embedded fragments, and from the polished and grooved and striated surfaces of some of them, that they were transported and deposited by the same agency as the boulders in the boulder clay of the Pleistocene or Glacial Period, namely, by the action of glaciers, and icebergs or shore ice and ice floes.

As the action of glaciers is a subject to which my colleague has paid so much more attention than I have, his opinion is entitled to much more weight on the point than any I could give, and I therefore would draw the reader's attention to Professor Ramsay's explanation of the origin of this breccia, in opposition to the conclusion that I myself arrived at, that the fragments might be derived from adjacent rocks now concealed under the Permian and New red sandstone of the neighbourhood.

* See also his lecture to the Royal Institution, April 24, 1857.

CHAPTER V.

Description of the Rocks—*continued.*

4. *The Coal-Measures.*

General Description.

The Coal-measures of North Staffordshire consist very largely of argillaceous (or clayey) materials, more or less mingled or alternated with arenaceous (or sandy) and carbonaceous (or coaly) substances. These different beds have various local names, of which the following is a nearly complete list:—

Argillaceous Materials.—Clunch,—a tough clay, breaking into blocks; sometimes rather sandy, generally grey or yellowish.

Binds,—shaly clay, close, smooth, compact, and splitting into regular laminæ, generally blue, or some shade of grey.

Clod, ground, earth,—earthy clay, generally of a blue or black colour.

Batt or bass,—highly carbonaceous* shale, commonly very compact, and splitting into the finest laminæ, almost invariably black, and often interstratified in layers with the coal.

Fire-clay,—clay having a certain definite proportion of silica and alumina in its composition with but little admixture of metallic or earthy fluxes, so that on the application of heat it forms a nearly pure silicate of alumina, and therefore makes good fire-bricks. It is generally unctuous to the touch as soon as it is got, which the other argillaceous beds rarely are. It is commonly a brownish grey, sometimes nearly black, but sometimes quite pale.

Arenaceous Materials.—The siliceous or arenaceous beds of the coal-measures have the following local names:—

Rock.†—All sandstones having any degree of hardness or toughness go under this name with the colliers.

Pebbley or bibbley rock,—sandstone with pebbles, conglomerate.

Rotch, or roach, is applied to sandstone when it is softer or more brittle than rock, so as to break easily into small fragments.

Peldon,—a very hard, smooth, compact, flinty stone, with conchoidal fracture.

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* It has been usual hitherto to call this "bituminous" shale, an incorrect term, inasmuch as, though it contains the components of bitumen, it does not contain that substance itself; one might almost as well in speaking of a sack of malt call it a barrel of ale.

† Under the term "rock" the miners likewise include all kinds of trap which occur in the district, using generally the distinctive terms "green rock" and "white rock," according to the colour. The only practical ambiguity that arises from this confusion of terms is in the case of the "white rock;" as, when that term is used, it is sometimes doubtful whether white sandstone or white trap is meant.

Some of these terms are used in composition to describe beds partaking of both characters, as—

Rock-binds,—sandy shale or shaly sandstone.
Clunch-rock,—hard sandy clay, &c. &c. &c.

Carbonaceous Materials.—There is every gradation from a mere carbonaceous shale or batt through a "slummy," smutty, or batty coal to a perfectly pure bright coal with but very slight admixture of earthy matter.

The coals are usually bituminous, that is, they still retain mingled with the carbon such a proportion of hydrogen and oxygen as would allow of bitumen being formed from them by distillation. Some of them, indeed, are cannel coal, which blazes almost like a candle, and consumes away so as to leave only a little light, white, powdery ash.

Usually, however, the coals are of the variety known as Cherry coal, (see Ronald's and Richardson's "Chemical Technology," vol. i. p. 45,) being got in large blocks, not caking, easily lighted, and burning with a clear, cheerful flame, leaving a white ash, and no very large proportion of cinders.

Ironstones.—The ironstones are all clay ironstone, occurring either in thin regular seams or in layers of nodules, balls, or concretions. The principal kinds have now been analyzed in great detail under the direction of Dr. Percy. (*See* "The Iron Ores of Great Britain," Part II.)

Usually in all local descriptions of the Coal-measures of South Stafford, whenever the word "stone" is used, ironstone must be understood.

Parting and pricking mean the thin layers between the more important beds; they are generally some variety of clay.

Grouping of the Measures.—The way in which the various beds of clay, shale, sandstone, coal, and ironstone are interstratified with each other, may be seen by reference to the four published sheets of Vertical Sections, Nos. 16, 17, 18, and 26. The Coal-measures of South Staffordshire, as of most other districts, are made up of a great series of alternating beds of these materials,—all of them varying in thickness and extent. As a general rule, the beds of coal are more constant in thickness, and extend over wider areas, than the beds of other materials. Next in constancy and persistency to the coals come the finest grained rocks, such as the batts, and the finer varieties of fire-clay and clunch. The sandstones and coarser grained rocks are most capricious in their occurrence, and vary most suddenly in thickness and character.

Beds of coal are not only constant in thickness over very considerable areas, but also generally in quality and character. This is so much the case, that colliers and other persons who have been long engaged in handling the coals of a district will recognize detached blocks of different coals lying loose on the pit bank, even when taken to a distance of some miles from their own pits. They will name the seam each block came from, when to

a less practised eye there seems no appreciable difference between them.

Changes, however, do occur both in the grouping and the quality of beds of coal. Changes in the grouping may occur either in the thickening or thinning of the measures between the coals, separating coals that were together, or bringing together those that were separate, or sometimes, but less frequently, even in the thickness of the coal-seams themselves, the very same bed becoming thicker in one place than another, or thinning out so as to occasionally disappear altogether. When, indeed, it becomes possible to trace a bed of coal over an indefinitely wide area, we must necessarily reach its termination by gradual thinning out in some direction or other.

Changes also occur in the quality and character of coals, so that sometimes, the very same bed or part of a bed, may within a comparatively short space become so altered in quality as to form quite a different variety of coal, and, of course, be no longer recognizable as the same, unless it be actually traceable by continuous working from one locality to the other, or can be referred to continuously traceable beds above or below it.

The South Staffordshire coal-field is distinguished from all others in the British Islands, and from most of those in the rest of the world, by the fact, that over a considerable part of its area a number of coals come together, resting one upon the other, with little or no interstratified shale or "parting" till they form a great seam of coal 30 feet in thickness. This has long been celebrated under the name of the *Thick* or *Ten-yard Coal.* The number of beds composing this remarkable compound seam are reckoned at from 10 to 14 in different places, according to the presence or absence of some of the beds, or of the separations between them. The "partings" of shale between the beds vary also occasionally in number and thickness, so that in some places the aggregate thickness of the coals is not more than 20 feet, with 10 feet of interstratified shales, &c.; while in others, the coals alone attain the dimensions of 36 feet, and with 3 feet of partings, make a total thickness of 39 feet.

The Thick coal retains this structure, more or less completely, over all the district around Dudley as far as Bilston, Wednesbury, Oldbury, Halesowen, Brierly Hill, and Kingswinford. In two of these directions, however, namely, westwards towards Kingswinford, and northwards, towards Bilston, the remarkable phenomenon known as the "Flying reed" seems to point out the commencement of a great alteration in the grouping of its beds. The two upper beds of the Thick coal are separated from the rest gradually, but rapidly, by interposed shales and sandstones, so that in the space of a mile or thereabouts they form a distinct seam, called the "Flying reed," which, towards the west, becomes as much as 100 feet above the Thick coal, and more than 200, towards the north.

Towards the north, also, between Bilston and Wolverhampton, a separation occurs in the middle of the Thick coal, a bed of shale

(sometimes called Hob and Jack), seven to ten feet thick, making its appearance between the "Foot coal" and the "Slips coal." These facts prepare us for the statement, of the truth of which good proof can now be given, that the change in the grouping of the beds was originally much more complete, even within the limits of the coal-field, and that the beds of coal which, coming together in the southern part of the field, form the Thick coal, are the very same beds, or some of them, which are worked now at Essington and Wyrley, and are there all more or less separated from each other by interposed shales and sandstones, so as to make a total thickness of over 300 feet. This change, from a thickness of thirty feet of coal only, to one in which thirty feet of coal are distributed among 300 feet of shales and sandstones, can be shown to have taken place within a horizontal distance not exceeding five miles. It is a kind of change quite familiar to those who are accustomed to trace any set of beds continuously along their strike, though it is not often that it can be so clearly proved and followed out in detail as in the present instance. Two of the coals below the Thick coal also undergo a similar separation towards the north.

Neither is this change in the grouping of the coals the only important change which occurs in the constitution of the field, for some of the lower beds of coal and ironstone which, in the part of the district between Wolverhampton and Walsall, are the richest and most important measures, dwindle away southwards towards Dudley, and farther south than that town have never been found at all in any workable form, though the measures of shale and sandstone in which they ought to lie have been pierced in search of them at several places.

These great changes in the constitution of the Coal-measures make it impossible to give any general section which shall be applicable in all its parts to any one locality. In the former edition of this Memoir this difficulty was evaded by giving, first, a list of the beds above the Thick coal, taken chiefly from the southern part of the field, and then a list of those below it, taken chiefly from the central and northern part. This plan, however, obscured the general view of the whole. It will, therefore, be better to give, first, a general section, compiled from the information to be obtained in the whole of the southern part of the coal-field from Bentley to Halesowen (Map 62, S.W.), and then another general and comparative section, applicable to the northern part of the district, from Bentley as far as Wyrley on the one side, and the Brown Hills on the other (Map 62, N.W.)

The first general section will include the mention of every workable bed of coal and ironstone in its proper place in the series, without regard to the locality in which it occurs. The second, while it agrees pretty nearly with the first in the lower measures (since each includes the Bentley district), will exhibit in the upper part the change before alluded to as occurring in the grouping of the coals forming the Thick coal, as well as some other changes in the lower beds.

As a more easily remembered key to the structure of the district than that of the general section it may be as well to give the following abstract list of the principal workable coals in the southern district in descending order:—

	FT.
Upper measures, maximum thickness - - about	800
1. Brooch coal - - - - - - about	4
Intermediate measures varying in 25 pit sections from 87 to 218 feet - - - - - - mean	130
2. Thick coal - - - - - - about	30
Intermediate measures varying in 33 pit sections from 7 to 35 feet - - - - - the mean being	20
3. Heathen coal - - - - - - about	4
Intermediate measures varying in 33 pit sections from 56 to 144 feet - - - - - the mean being	109
4. New Mine coal - - - - - about	8
Intermediate measures varying in 43 pit sections from 2 feet to 35 feet - - - - - the mean being	16
5. Fire-clay coal - - - - - about	7
Intermediate measures varying in 40 pit sections from 18 to 52 feet - - - - - the mean being	30
6. Bottom coal - - - - - - about	12
Lower measures - - maximum proved thickness	140
	1,310

This total of 1,300 feet is probably greater than the thickness of Coal-measures that ever existed at any one place in the southern half of the South Staffordshire coal-field.

GENERAL SECTION of the Central and Southern Part of the Coal Field.

		FT.	FT.
1.	* Beds above the Upper Sulphur coal - - - -	1*a*. The Halesowen sandstone group 1*b*. The Red coal-measure clays	600 to 800
2.	† Upper Sulphur coal - - -		about 1
3.	Intermediate measures - - - -	„	140
4.	† Little or Two-foot coal - - -	-	2
5.	Intermediate measures - - - -	from	2 to 48
6.	(I.) BROOCH COAL - - - -		about 4
7.	(*I. 1.*) Brooch binds, ironstone measures -	from	7 to 20
8.	† Herring coal ‡ (not known north of Dudley) - - - -		about 1
9.	(*I. 2.*) Pins and Pennyearth ironstone measures § - - - -	from	7 to 30
10.	Intermediate measures containing the sandstone known as the Thick coal rock -	„	38 to 157

* Each group of beds is numbered in consecutive order, the workable coals having an additional number in Roman figures, and the ironstones an additional number with *I.* before it.

† The coals thus marked are not numbered, as they have never yet been worked.

‡ So called from containing many dorsal spines of fish, called herring bones by the colliers.

§ These ironstones are occasionally rich in the remains of fishes.

			FT.	FT.
11.	(*I. 3.*) Broad earth, Catch earth, and Batt, containing the Ten-foot, and Backstone ironstones in the Pensnett district -	from	6 to	14
12. Thick Coal.	(II.) Roofs coal or top floor - -			
	(III.) Top slipper, or Spires, or Spin coal - These two form the Flying reed when separated from the coals below.			
	(IV.) Jays, or White coal - - -			
	(V.) Lambs, or Floors, or Fine Floors coal These two are often either mentioned together under the name of White coal, or else the lower one is absent.			
	(VI.) Tow (tough) or Heath coal - -			
	(VII.) Benches coal (this bed is but rarely mentioned).		about	30
	(VIII.) Brassils or Corns coal - -			
	(IX.) Foot coal, or Bottom Slipper, or Fine coal.			
	(X.) John coal, or Slips or Veins coal -			
	(XI.) Stone, or Long coal - -			
	(XII.) Patchells coal (sometimes absent or not mentioned).			
	(XIII.) Sawyer or Springs coal - -			
	(XIV.) Slipper coal - - -			
	(XV.) Bottom Benches, or Omfray (Humphrey), or Red, or Kid (Kick?), or Holers coal.*			
13.	(*I. 4.*) Pouncill batt, Blacteryand Whitery, containing the Grains ironstone, and sometimes the Whitery iron stone.† -	from	2 to	8
14.	(*I. 5.*) Gubbin ironstone measures, sometimes called the Little, or Top, or Thick coal gubbin, sometimes the Black ironstone - - - - -	„	2 to	8
15.	Table batt and intermediate measures - -	„	2 to	28
16.	(XVI.) Heathen Coal - - -		about	3
17.	Intermediate measures (sometimes wanting) -	from	0 to	43
18.	(XVII.) Rubble, or Lower Heathen coal, sometimes, when the measures above are wanting, forming the bottom part of the Heathen coal, sometimes itself wanting, when the measures above and below seem to be both present - - - -	„	2 to	4

* Beds numbered as XV., XIV., XIII., XI., X., IX., VIII., VI., with either IV., or IV. and V. grouped as the White coal, are always present wherever the Thick coal is at all in the normal condition; where III. and II. have gone off as the Flying reed, the White coal is always the top measure; the beds numbered VII. and XII. are often omitted, either being absent or being grouped with the one above or below them.

† About Bentley there is an ironstone in these measures which is there called the Bind ironstone, and it has a coal called the Bind coal associated with it, which is sometimes 14 inches thick.

		FT.	FT.
19. (*I. 6.*) Intermediate measures containing, at Bentley, the ironstones known as the Lambstone and Brownstone	from	10 to	33
20. (*I. 7.*) New Mine or White ironstone	„	2 to	10
21. (*I. 8.*) Measures containing the Penny-stone ironstone, called also Bluestone or Cakes	„	10 to	25
22. (XIX.) SULPHUR coal	„	2 to	9
23. Intermediate measures	„	3 to	99
24. (XX.) NEW MINE coal *	„	2 to	11
25. (*I. 9.*) Measures containing the Fireclay Balls ironstone occasionally	„	2 to	40
26. (XXI.) FIRECLAY coal (and partings)	„	1 to	14
27. Intermediate measures	„	2 to	10
28. (*I. 10.*) Getting Rock ironstone (occasional)	„	4 to	5
29. (*I. 11.*) Poor Robin ironstone measures	„	3 to	5
30. Intermediate measures, sometimes wanting	„	0 to	9
31. (*I. 12.*) Rough hills White ironstone (occasionally)	„	2 to	19
32. (XXII.) BOTTOM coal	„	3 to	12
33. Intermediate measures	„	5 to	30
34. (*I. 13.*) Gubbin and Balls ironstone, sometimes called the Great or Bottom Gubbin	„	3 to	10
35. Intermediate measures	„	18 to	50
36. (XXIII.) SINGING or MEALY GREY coal (occasional)	„	2 to	4
37. Intermediate measures	„	16 to	50
38. (*I. 14.*) Blue Flats ironstone	„	2 to	9
39. Intermediate measures	„	10 to	14
40. (*I. 15.*) Silver Threads ironstone	„	4 to	7
41. Intermediate measures	„	6 to	15
42. (*I. 16.*) Diamonds ironstone	„	2 to	3
43. Lowest measures, maximum thickness known below the Diamonds ironstone		about	50

The variations in thickness, noted in the preceding general section do not take place indiscriminately, but chiefly according to a general rule, the least thickness being almost invariably found to the south, while the greater thicknesses come in regularly as we proceed northwards. There are, however, local exceptions to this statement, in the fact of a sudden thickening or thinning of any particular group of beds in a partial manner, and over a small area, with an immediate return to the normal thickness of the neighbourhood. The group of sandstones known as the Thick-coal rock, and some other sandstones, have these partial thickenings, while the shales between the New Mine and Fire-clay coals, sometimes, as in the Stowheath field, diminish quite unexpectedly to two feet, and then suddenly regain their usual dimensions of 30 or 40 feet. Sometimes, indeed, these two coals are so split up by partings, that when the thickness between

* The New Mine coal is completely separated into two coals at Bentley, there called the Three-foot and the Five-foot, with 33 feet of shale and sandstone, containing ironstone between them.

them is small, it is not easy to determine which is the bottom part of the New Mine and which the upper part of the Fireclay.

Besides this original irregularity in the constitution of the coal-measure series, the present "lie and position" of the beds is such that the uppermost beds of all, the Halesowen sandstones namely, which come in far above the Upper Sulphur coal, are only now to be found around the southern margin of the field, where the beds dip to the south, while all the upper measures and the Thick coal itself have been removed by denudation from the district between Bilston and Bentley, where the lower beds gradually rise to the surface as we proceed towards the north. Neither do the Halesowen sandstones ever appear again further north although the great Bentley fault throws down the beds in that direction, so as to bring in the Thick coals and some of the beds above them, and although as we range to the north, the dip of the measures seems to be first west and then north-west.

We will now proceed to examine the general section of this northern part of the district, that namely, which lies north of the great Bentley fault, as far north as Cannock Chase. In order to make this general section at the same time a comparative one, and point out the locality whence each piece of information is derived, the following distinctive letters will be used; E. for the Essington district, W. for Wyrley, B for Bentley, and P. for Pelsall and the Brown Hills, while the average thickness will be that of all the places where the beds have been mentioned in the pit sections obtained.

GENERAL SECTION of the Coal-measures extending from Bentley to Essington and Wyrley on the West, and Pelsall and the Brown Hills on the East.

		Average thickness. FT.	IN.
1.	Various measures; 20 ft. E. - - - -	20	0
2.	(I.) Coal; 2 ft. E. - - - -	2	0
3.	Intermediate measures; 37 ft. E. - - -	37	0
4.	(II.) Coal; 1 ft. 9 in. E. - - - -	1	9
5.	Intermediate measures, 10 ft. E. - - -	10	0
6.	(III.) Coal, 5 small coals with partings, 12 ft. 6 in. E.	12	6
7.	Intermediate measures, 3 ft. E. - - -	3	0
8.	(IV.) Coal, 1 ft. E. - - - -	1	0
9.	Intermediate measures, 66 ft. E. - - -	66	0
10.	(V.) Coal, 2 ft. E.; 1 ft. 9 in. W. - -	1	10
11.	Intermediate measures, 32 ft. E.; 10 ft. W. - -	21	0
12.	(VI.) Coal, 7 ft. 6 in. E.; (coals and partings 9 ft. 10 in.) W. - - - -	8	8
13.	Intermediate, with a small coal, 57 ft. E.; 76 ft. W. -	67	0
14.	(VII.) Old Robins coal, 5 ft. 6 in. E.; 6 ft. 6 in. W. -	6	0
15.	Intermediate, 35 ft. E.; 18 ft. to 22 ft. W. - -	25	0
16.	(VIII.) Wyrley Yard coal, with parting, 5 ft. E.; 3 ft. to 5 ft. 6 in. W. - - -	4	0
17.	Intermediate, including the Yard coal ironstone, 40 ft. E.; 36 ft. to 69 ft. W. - - -	47	0
18.	(IX.) Charles coal, 2 ft. 3 in. E.; 2 ft. 4 in. to 3 ft. W. - - - - -	2	6
19.	Intermediate, 30 ft. E.; 24 ft. to 64 ft. W. - -	52	0

		Average thickness. FT.	IN.
20.	(X.) Cannel coal, 3 ft. 8 in. E.; 4 ft. W. - -	3	11
21.	Intermediate, 60 ft. E.; 54 ft. to 84 ft. W. - -	71	0
22.	(XI.) Wyrley Brooch coal, 2ft. E.; 3 ft. 8 in. to 4 ft. W. - - - - -	3	4
23.	Intermediate, 3 ft. 6 in. E.; 1 ft. to 1 ft. 6 in. W. -	1	8
24.	(XII.) Benches coal, 7 in. E.; 2 ft. to 2 ft. 4 in. W. -	2	0
25.	Intermediate, with a 2 ft. coal, 74 E.; 40 to 48 ft. W. -	54	0
26.	(XIII.) *Wyrley Bottom or Eight-foot, Bentley Old Man's coal; 8 ft. 6 in. with partings E.; 6 ft. to 8 ft. W.; 9 ft. 10 in. B. - -	8	1
27.	Intermediate, 38 ft. E.; 39 ft. to 46 ft. W.; 45 ft. to 61 ft. B. - - - -	46	0
28.	(XIV.) †Essington Four-foot, or Bentley Hay coal, 4 ft. E.; 3 ft. W.; 5 ft. sometimes expanded by shale to 11 ft. B. - -	4	0
29.	Intermediate, 51 ft. to 63 ft. B. - - -	54	0
30.	(XV.) Heathen coal, 1 ft. 8 in. to 3 ft. B.; 2 ft. 6 in. P.	2	0
31.	Intermediate, 44 ft. to 56 ft. B.; 61 ft. P. - -	50	0
32.	(XVI.) Sulphur coal, 1 ft. 6 in. to 4 ft. B. - -	1	9
33.	Intermediate, 21 ft. to 52 ft. B.; 32 ft. to 52 ft. P. -	43	0
34.	(XVII.) Yard coal of Pelsall, 3 ft. to 3 ft. 6 in. B.; 2 ft. 9 in. to 3 ft. 8 in. P. - -	3	2
35.	Intermediate, 31 ft. to 46 ft. B.; 26 ft. to 50 ft. P. -	40	0
36.	(XVIII.) Bass coal of Pelsall, 4 ft. to 6 ft. B.; 3 ft. to 6 ft. P. - - - -	5	10
37.	Intermediate, 21 ft. to 35 ft. B.; 29 ft. to 39 ft. P. -	31	0
38.	(XIX.) Fireclay or Cinder coal, 3 ft. 10 in. to 6 ft. 8 in. B.; 3 ft. 2 in. to 5 ft. P. - -	4	6
39.	Intermediate, 21 ft. to 46 ft. B.; 21 ft. to 49 ft. P. -	33	0
40.	(XX.) Upper part of Bottom coal, or Shallow coal, 2 ft. to 7 ft. 9 in. B.; 4 ft. to 7 ft. P. -	5	4
41.	Intermediate, 8 in. to 8 ft. B.;‡ 38 ft. to 51 ft. P. (average of latter) - - -	46	0
42.	(XXI.) Lower part of Bottom, or Deep coal, 2 ft. 9 in. to 4 ft. 8 in. B.; 5 ft. to 15 ft. P.§ -	6	8
43.	Measures between the Bottom coal and the Silurian shale, 137 ft. B. - - -	137	0
		1,053	0

* This, which is the lowest coal hitherto worked at Wyrley, is the uppermost coal of all in the Bentley district, only coming into the ground, here and there, when the lower beds dip deep enough to allow it to do so.

† This coal has been sunk into at Essington, and has also been twice reached, once by boring, and another time by sinking, near Wyrley, where it was found to be only 3 feet thick. The finding of this coal there at the proper distance below the so-called Bottom coal of Wyrley lends a strong support to the identification of that coal with the Old Man's coal of Bentley.

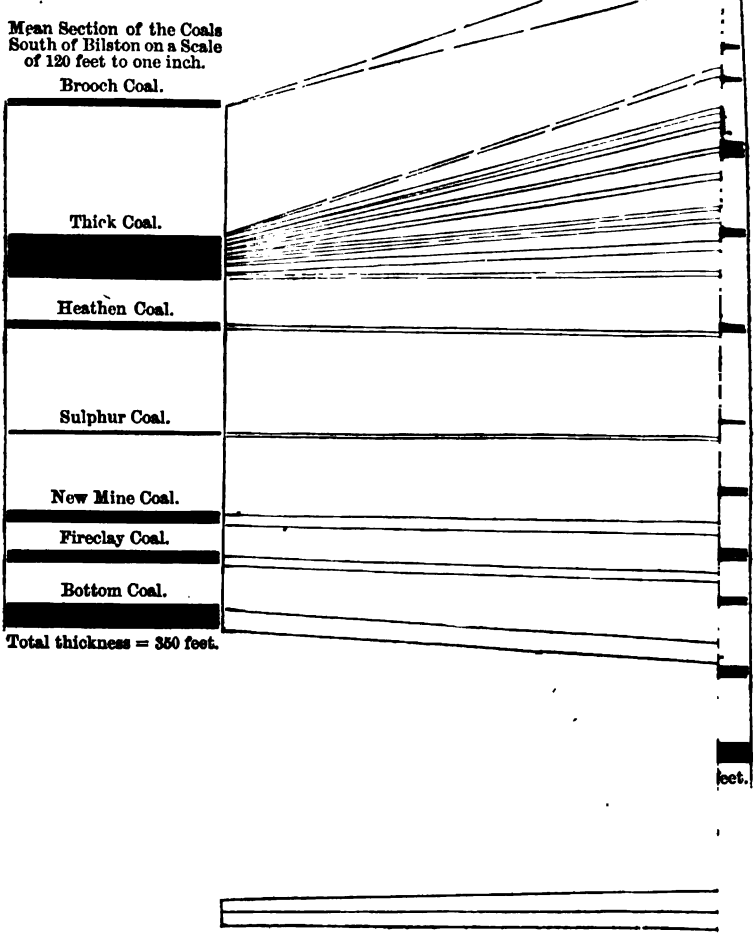
‡ In the Bentley district the Bottom coal is still looked upon and worked as one seam, even when the central parting is several feet thick. It is only N.E. of Goscott that the two parts become so widely separated that they are worked as two beds under the names of the Shallow and the Deep coal. Between Bentley and Goscott the Bottom coal is in one place even called the Thick coal, being the thickest bed known thereabouts.

§ Where the Deep coal thickens to 12 or 15 feet it is in consequence of a considerable parting separating the bottom part of it from the rest. It is probable that further north this separation will become so considerable that the coals will be separately gotten and receive separate names.

(*To face page* 25.)

PLATE

FIG. 1.—Diagram to show the relation between th
north-central part of the South Staffordshire coalfield
from many pit Sections scattered over an area of thre
mean or average thickness of those pits. They are
distance between the two areas is about five miles, sc
ought to be placed about 18 feet from each other, wh
shown in Figure 2.



If we compared the two general sections now given, on the supposition that the Thick coal of the first was but one coal, we should have only 7 or 8 workable coals in that section to contrast with 21 in the other. By taking into account that the Thick coal is made up in reality of 12 to 14 separate coals, we at once get the fact that the number of coals are in reality nearly the same in both sections. The difference in the two series is then seen to be the result of variations in the other materials, namely, the shales and sandstones with which the coals are interstratified.

It may very well be doubted whether any single bed of coal is ever more than two or three feet in thickness, and we may therefore take it for granted, that every bed which exceeds that thickness over any considerable space is in reality a compound seam made up of two or more beds resting on each other, with or without "partings" of shale, &c. between them. Not only then are many of the beds which are spoken of under one name in the southern part of the district compound seams, but several of those in the northern district also. We may look upon the seams numbered III., VI., VII., VIII., XIII., and XXI. in the second general section as undoubtedly compound seams, liable at any place to be separated into two by interposed shale and sandstone. Some of the others may also be compound seams.

In comparing the two general sections we must recollect that the second does not include any of the 600 or 800 feet of upper measures which form the top of the first, and we shall then see that the bulk of the coal-bearing beds in the second is much greater than the bulk of the coal-bearing beds in the first. Since, however, the quantity of coal disseminated through that bulk is nearly the same in both, or at least is but slightly preponderate in the second, it follows that the increase is in the shales and sandstones interstratified with the coals. Since, moreover, the lower beds are the same in both sections, it follows that the beds above them, those about the Thick coal, are on the same geological horizon, and that the Thick coal of the first is split up somehow into the separated beds of coal to be found in the second.

In Plate I. Figure 1 will be found a representation of this splitting up of the Thick coal and other coals towards the north in a diagrammatic form. The constitution of the beds south of Bilston (which we may call the south central portion of the coal-field) is shown on the one hand in a vertical section on a scale of 120 feet to an inch, and that of the beds at Bentley and north of it, on the other hand, in a similar vertical section on the same scale, each section being a mean or average section deduced from a considerable number of actual pit sections.

The coals known as the Heathen and Sulphur are common to the two sections, the Heathen being assumed as the horizontal datum line.

The Fire-clay and Bottom coals are also common to the two sections being worked continuously from Bilston to Bentley, and thence to Pelsall.

Just at the south end of Pelsall Heath, the Bottom coal, which up to that point has been worked continuously as a single twelve-foot coal, begins to separate into two coals, which about a mile or so farther north are as much as 15 yards (45 feet) apart. These two coals were formerly gotten along their outcrop at the Brown Hills, under the name of the Shallow and the Deep coal. The Deep coal itself is also, a little farther north, beginning to separate into two coals.

The Fire-clay coal has been worked continuously from Bilston up to Bentley, and thence by Goscott to Pelsall, but on reaching the latter place it apparently begins to change its quality and character, and further north is known only as the Cinder coal.

The New Mine coal crops out a little before it reaches so far north as the Great Bentley fault, and when thrown in by that fault, it is found to be separated into two, called at Bentley the Three-foot and Five-foot, but known farther north as the Yard and the Bass coal. That these two coals are in reality the two separated parts of the New Mine coal is shown by the fact that at Bentley they have the Sulphur and Heathen coals next above them, and the Fire-clay coal next below them.

With this tendency to split up into separate coals as we proceed towards the north, clearly proved to exist in the lower beds which run continuously in the ground, we can the more readily allow the probability of a similar tendency in the upper beds, which now only occur in localities more widely separated from each other in consequence of the removal of large portions of the measures by the denudation that has acted over the intermediate space.

In consequence of the denudation having removed so much of the upper measures it is difficult, perhaps impossible, to identify the beds of those upper parts of the two districts with the same precision that we can the beds in the lower measures. It is, however, very remarkable that if we add together the average thickness of the coals in the Wyrley and Essington district, commencing with the Old Robins coal, and including the Essington four-foot or Bentley Hay coal, which there lies next above the Heathen coal, we shall, if we omit the partings, get a thickness of a little over thirty feet (about thirty-three feet), which agrees quite as closely with that of the Thick coal as we could expect.

Whether the Brooch coal of the district south of Bilston, be represented by the Essington sixth coal, or whether the fifth and sixth coals of that locality be new coals, and the third and fourth represent the Brooch, is perhaps a moot point.

If the Old Robins coal be really the top of the Thick coal, or the same as the Flying reed coal, then the Essington sixth coal is at rather a less height above it than the Brooch is above the Thick coal in the southern part of the field. Bearing in mind, however, the tendency to thicken and increase towards the north which the measures below exhibit, we should expect the height to be greater, and should be more inclined, perhaps, to look upon the fifth and sixth coals of Essington, either as themselves the representatives of the Flying-reed, or upper part of the Thick coal, (which will

then not merely be separated by shales, but have a greater thickness of coal than it generally has farther south,) or else consider them as new coals not represented at all in the southern part of the field.

Whatever may be the truth with regard to those points of detail, the general fact of the beds at Essington, Wyrley, and Bentley, from the Old Robins coal down to Bentley Hay coal inclusive, being the representatives of the Thick coal can no longer be doubtful.

It appears that the materials which formed the shales and sandstone, &c. were deposited abundantly and frequently towards the north, but that some of them gradually became less and less towards the south, so that in many cases they finally came altogether to an end in the latter direction, while the coals were deposited equally, or nearly so, over both areas.

The fact now established is one of considerable interest, both as regards the practical working of this and other coal-fields, and as bearing on the theoretical explanation of the origin and formation of coal.

Note on the Fossils, by J. W. Salter, Esq.

The fossils of the ironstones as a whole very much resemble those of the Coalbrooke Dale coal-field. There is the same intermixture of marine shells, shark-like fish, and a few land plants, with a considerable number of unio-like shells (*Anthracosia*), too imperfect for determination in most cases. One species, however, is the *A. bipennis*, Brown, found, both here and in Flintshire, in the coal itself. The marine shells are quite the same as those of the "Pennystone" of Coalbrooke Dale, but they are fewer in number.

The following may be considered characteristic of the ironstones :— *Discina* (*Orbicula*) *nitida* of Phillips ; *Producta scabricula*, Sowerby ; a *Lingula*, which appears to be the *L. elliptica* of Phillips ; *Conularia quadrisulcata*, and the two species of *Myalina* figured by Prestwich, viz., *M. quadrata* and *M. carinata*. The *Aviculopecten scalaris*, Sowerby, is rare. With these are abundance of the large fish defences, called *Gyracanthus formosus*, Agass. ; scales of a large *Holoptychius ;* the *Megalicthys Hibberti ;* and *Cochliodus*. (*Pœcilodus angustus* occurs in bastard coal at the Fens colliery.) There are also traces of *Annelides*, and the usual plants, *Lepidodendron*, *Calamites*, &c., occur.

The localities from which these fossils have been obtained are ;—the pit banks three-quarters of a mile N.E. of Portway Hall near Oldbury, and the Factory north of that place. The *Producta* and *Conularia* are abundant at the former, and the large *Mytilus*-like bivalves (*Myalina*), with the *Lingula* and *Fish*, at the latter.

South and south-west of Dudley, at Queen's Cross, *Holoptychius* and *Myalina* occur in the Gubbin ironstone ; and at the Buffery ironworks the large *Gyracanthus formosus*. The Fens south-west of Dudley have a few shells in the carbonaceous bands, and also a fish-palate, *Pœcilodus angustus*, a species equally characteristic of similar beds (the *top* coal) in Coalbrooke Dale. It is also found in coal in Flintshire.

Further west, Kingswinford colliery affords only *Anthracosia*, *Modiola*, and the *Gyracanthus formosus*. At Moor Lane, Brierly Hill, the *Holoptychius* and *Lingula*.

Further south, near Oldswinford, White Hall colliery has the usual Brachiopods, *Lingula* and *Discina*, with *Conularia*, *Anthracosia bipennis* (in coal), and the *Aviculopecten scalaris*.

Bare Moor colliery, only Brachiopods, Productæ, &c.

CHAPTER VI.

DESCRIPTION OF THE ROCKS—*continued.*

Detailed Description of the Coal-measures.

1. ***Beds above the Upper Sulphur coal,*** including the Halesowen sandstones and the Red Coal-measure clays.

Wherever the bed known as the Upper Sulphur coal is mentioned in the pit sections, it is found to lie about 300 feet above the Thick coal, and about half that distance above the Two-foot or Little coal. The Upper Sulphur coal is mentioned in most of the pit sections in the latitude of Dudley, from Great Bridge to Kingswinford.

At the Trough pits near Burnt Tree it is 343 feet above the Thick coal, but this thickness diminishes as we come south to about 290 at Corbyn's Hall and Wordesley Bank.

Farther south still, towards Corngreaves and the Hawne the Upper Sulphur coal seems to disappear, but the Two-foot continues, lying at a height of about 150 feet over the Thick coal at Congreaves, at the Old Lion colliery, and at a pit a little north of the Sleck Hillock formerly worked by Mr. Mills.

We may conclude, therefore, that the Two-foot coal will retain this position over all the southern portion of the field, and that the place of the Upper Sulphur coal (whether it be present or absent) will never exceed a height of about 300 feet above the top of the Thick coal.

1*a*. ***Halesowen Sandstones.***—There are beds, however, in which at least one coal occurs, which are much above this height over the Thick coal. A little bed of coal is to be seen in a small ravine nearly due east of Ham House near Old Swinford, in the brooks running down from Lutley to Lutley Mill, in the brooks in Uffmoor Wood, and Mr. Mathews, of the Leasowes, informed me that he came upon a similar little coal in some excavations in the Leasowes demesne. Mr. Richards also formerly sank at Wassel Grove, and passed through two little coals, one of four inches and the other eighteen inches thick. Now the rocks associated with these little coals are principally olive green, brownish, and yellowish sandstones, sometimes pebbly or conglomeritic; and this sandstone group stretches all across the southern portion of the coal-field by Prescott and Wollescote and Careless Green, Wassel Grove, Upper and Lower Lutley, Halesowen, and the Leasowes, and caps the hills of High Haden, Homer Hill, and Cradley Park.

This sandstone group seems to have a thickness of not less than 200 or 300 feet, and from underneath it there appear red and green and mottled clays likewise of considerable thickness, as may be seen by the spoil banks of the pits on the north side of Gosty Hill, and thence at various places north of those just mentioned to Cradley and the Lye Waste and Hay Green.

The little coal or coals which are to be seen high up in the sandstone group have sometimes been spoken of as if they were the representative of the Upper Sulphur, or the Two-foot, or even the Brooch coals. It may be shown by the following facts that this cannot be the case, and that the coal of Wassel Grove, and the other places mentioned above, is far higher above the Thick coal than even the Upper Sulphur coal.

At Mr. Attwood's colliery at Hawn the depth of the shaft to the bottom of the Thick coal is 255 yards = 765 feet; but as the beds dip south at the rate of 3 inches in a yard, and they have driven a "gate-road" in that direction 450 yards without meeting any fault or change of dip, the end of the gate-road must be 112 feet below the bottom of the

shaft. But inasmuch as the surface of the ground rises rapidly to the south, while the beds fall, that rise being at least 100 feet in the 450 yards, we get over the head of the gate-road a thickness of beds above the Thick coal of *not less than* 977 feet.* Let us, then, suppose the beds to be absolutely horizontal from the end of the gate-road to Hasbury Hill, south-west of Halesowen, which those near the surface certainly are for the greater part of the distance, we must still add another 70 feet for the total rise of ground from Hawn to Highfields, Hasbury,† when we shall have a thickness of at least 1,000 feet between the uppermost beds seen there and the *top* of the Thick coal.

The details of the beds passed through in the Hawn shaft are not known, but the high ground on all sides of it is composed of greenish brown sandstone, dipping generally at a very gentle angle to the south. In the lane leading from Hawn to Gosty Hill, these sandstones are conglomeritic, and many of the pebbles consist of fragments of trap, not, however, of basalt or greenstone, but of brown and purple porphyry (or felstone) very like some of those so abundant in the Permian rocks of the Clent Hills. It appears, therefore, that fragments of such rocks began to be drifted from some rather distant locality even during the Coal-measure period.

These beds and those quarried near Halesowen are probably below the sandstones of Lutley and Wassel Grove, in which the little beds of coal before mentioned occur, for the places where these coals occur are both further south and on higher ground than that round Hawn and Halesowen.

Mr. G. Thompson, formerly manager of the British Iron Company's Works at Corngreaves, communicated the following section of the pit sunk at Wassel Grove.

	FT.	IN.
1. Sand rock and other rocks	123	0
2. Blue rock-binds	4	0
3. Sand rock	38	0
4. Little coal	0	4
5. Blue rock with black shades	5	0
6. Grey peldon	0	8
7. Rock binds	2	0
8. Rough mingled rock	13	0
9. Blue rock	4	0
10. Fire-clay	6	0
11. Soft white rock	13	0
12. Bind measures with two ironstone bands	4	0
13. Coal	1	6
14. Fire-clay	4	0
15. White rock	15	0
16. Mingled ground with binds	5	0
17. Rock with sheds (bored into)	45	0
	283	6

* To the original 765 feet we must add 112 for the fall of the beds, 100 for the rise of the ground = 977 feet: deducting 30 feet for the thickness of the coal, we get in round numbers 950 feet for the thickness above the coal.

† The Hawn pits are 370 feet above the sea. Captain Ibbetson made the spot at "H" of "High fields" in the Ordnance map 540 feet above the sea; difference =170 feet.

From the preceding considerations it is scarcely possible that the place of the Thick coal can be at a less depth than 800 or 900 feet (say 300 yards) beneath Wassel Grove, and all the line of country mentioned before where these little upper coals are observed to crop out.

1*b*. *Red Coal-measure Clays.*—These facts are represented in Horizontal Section No. 10, sheet 25, which was taken over Hasbury Hill, where there is a capping of red rock believed to be Permian, and thence across Hawn to the Old Lion colliery. In the latter shaft (of which a vertical section is given on Sheet 18 of the Vertical Sections, No. 25) there are about 50 or 60 feet of dark and grey rocks at the top containing a little nine-inch coal, underneath which come about 280 feet (or 93 yards) of red and blue marls, interstratified with "blue ground," "blue rock," and "mottled ground," many of the so-called blues being rather green than blue, but the predominating colour of the whole a deep purplish red. The bottom of this red group is about 233 feet (or 77 yards) above the Thick coal. A similar group of red and blue beds, mostly clays, but sometimes sandy, is noted in the sections at Congreaves and Baremoor. Red and blue mingled ground is mentioned in the Barrow Hill pit (No. 23, Sheet 18, of Vertical Sections,) in the shafts about Corbyns Hall, at Wordesley Bank, and almost wherever a detailed section is given of the beds lying 100 yards or so above the Thick coal in the southern part of the district.

North of Dudley, again, in the Trough pits at Burnt Tree, where the Thick coal is 617 feet deep, the upper 360 feet are said to consist largely of "mottled ground," "mingled ground," "blue and mingled ground," the "mottling" and the "mingling" almost always alluding to the occurrence of red with the other colours, and the term "ground" signifying an argillaceous material, and not a sandstone (see Vertical Section No. 14, Sheet 17). These reddish clays are worked in large excavations at the surface near Tipton and south of Oldbury, as well as between the Lye Waste and Stourbridge, and used for making a very superior kind of brick, generally of a deep blue colour. In the deep sinking at Great Bridge, near West Bromwich, where the Thick coal is 567 feet deep, there is a bed of "red marl" 6 feet thick, at a height of 205 feet above the Thick coal; and 38 feet above that again, or about 243 feet (or 80 yards) above the Thick coal, there is a group of red marls 64 feet thick, with a few beds of "blue" or "mottled rock." The Upper Sulphur coal then comes in with a "white fire clay" below and a "blue clunch" above, covered by about 63 feet of beds containing no red, over which are 192 feet of other measures, in which beds of "red marl" 8 to 16 feet in thickness, are very frequent.

We may, therefore, assume it as a fact, supported by all the available evidence we possess, that there was deposited a group of beds in the South Staffordshire coal-field lying about 100 yards above the Thick coal, being themselves about 100 yards in thickness, and principally composed of red or red and green (or blue) clays, variously interstratified with beds of other colours, and occasionally containing small coals, fire-clays, &c.

This fact is very important, for it enables us to classify some beds in the northern part of the district in their right place as Coal-measures, notwithstanding the red colours which formerly led us to look upon them as belonging to the Permian (or even, still earlier, to the New red) formation. These are the red clays about Walsall Wood,* those of

* Professor Ramsay and Mr. Hull have lately (February 1859) gone over this ground again for the express purpose of comparing these several localities with each other, and with the red beds in the southern part of the coal-field, and have satisfied themselves that they all belong properly to an upper part of the Coal-measure series.

Essington Wood, those of Rumour Hill near Cannock, and of Littleworth on Cannock Chase. They are largely opened for brick pits, the bricks being hard blue bricks of a superior quality and peculiar appearance. The beds in those northern localities consist principally of dark purplish-red clay, mottled and streaked occasionally with green, and interstratified not unfrequently with soft reddish or brown sandstones. They appear to constitute a group of very considerable thickness, since they have been sunk through for more than 200 feet at the Coppy Hall colliery, just at their edge, and have probably a total thickness of at least double that. They are nowhere known to be covered, in the northern part of the coal-field, by any group of greenish or brownish sandstone, as they are near Halesowen and the neighbourhood, but possibly they may have been so originally, after having, like the other coal-measures, swelled out to a greatly increased bulk on the north over that which they possessed on the south side of the district.

Having thus traced the beds over the Upper Sulphur coal, together, perhaps, with some of those in which it lies over the whole coal-field, we will now turn to the detailed descriptions of the beds mentioned in the first general section given at page .

2. *The Upper Sulphur Coal.*—The Upper Sulphur coal is itself a small and insignificant bed, rarely if ever exceeding 1 foot 6 inches in thickness; it has never been "gotten," nor would it be worth the trouble of extracting. Like most other small coals, it is local only, and is altogether wanting in some shafts that go through the beds in which it is found at other places.

3. *Intermediate Measures.*—The intermediate measures, between the Upper Sulphur coal and the Two-foot, have a mean thickness of about 150 feet, which thickness, wherever the two coals are undoubtedly present, does not seem to vary more than 37 feet. The variations in thickness seem to be due to the greater or less abundance of sandstones. The beds are chiefly argillaceous, being designated usually by the terms "bind," "clunch," "ground," "fire-clay," &c., but having several interstratified beds of various kinds of "rock" or sandstone. Like the beds before described, as we go south the sandstones begin to thicken and predominate, and become in some instances conglomeritic.

4. *Little or Two-foot Coal.*—Although this coal has never been worked or "gotten," its thickness not being sufficient to allow it to be got with profit, it is yet a very persistent bed, as its presence is noted in all the detailed pit sections we have which pass through its place. It varies from 1 to 2 feet thick, but I know nothing of its quality, nor whether any trials of it have been made.

5. *Intermediate measures between the Little coal and the Brooch.*—These beds are almost universally clunch, binds, fire-clay, or some argillaceous material; but in one or two cases they contain beds of rock or sandstone. Their thickness in all the central portion of the field varies from 13 to 48 feet, the mean being about 25 feet. As we go south and west, however, into the district of Congreaves, Cradley, and the Black Delph, the thickness of these beds rapidly diminishes, and they vary only from 2 to 7 feet, consisting of fire-clay or batt, or both. In some places in the neighhourhood of Kingswinford, as also in the district last referred to, a little coal makes its appearance occasionally in these beds, but is too unimportant to require a separate notice.

6. (I.) The Brooch Coal.*—This is the uppermost workable coal in the coal-field; it is almost invariably of excellent quality, and in

* Sir R. I. Murchison, in his account of this district in the "Silurian System," derives this word from the measures having been first "broached" or entered on by this

great request in the district for parlour fires. It varies in thickness from 2½ to 6 feet, the mean and by far the most usual thickness being about 4 feet. It is quite constant over the whole coal-field, wherever the beds occur in which it ought to be found.

7 and 8. (*I.* 1.) ***Brooch binds ironstone measures and Herring coal.***—These beds are almost entirely confined to one portion of the district, that, namely, on the west and south of Dudley. The Brooch binds are shales averaging about 7 feet in thickness (Vertical Sections, sheet 26, No. 49). In some places, as at Corbyns Hall, and Bromley Hall near Kingswinford, as also in the Corngreaves district, they contain ironstone nodules, which sometimes, but not always, are worth getting. About Brierly Hill and at Wordesley Bank Colliery they thicken out to upwards of 20 feet, and contain good ironstone. The Herring coal is generally about 18 inches thick, and not worth getting; it is, however, very persistent in the district now described, and as we go towards High Haden we find other small coals, one of which is a cannel coal, coming in just below the Herring. Neither of these measures are mentioned in the section of the Oak-farm pit, nor in the borings at Holbeche Mill near Himley, on the west side of Dudley, nor do they occur at all on the east side of Dudley, except in one part of Tividale, where, in the record of an old sinking in 1797, given in Plott's History of Staffordshire, I find mentioned the following beds:—

	FT.	IN.
a Brooch coal - - -	3	9
b Black clunch - - -	7	0
c Coal - - - -	1	3
d Pennyearth with ironstone -	7	0

of which *b* and *c* must be the beds we are speaking of.

9. (*I.* 2.) ***The Pins and Pennyearth ironstone measures.***—These take their names from the form of the ironstone nodules which they contain, the Pins being small cylindrical nodules, and the Pennyearth small round flattish nodules, like penny pieces. These measures have a wider spread than those last mentioned, since they are noted in sections east of Dudley, not only at Tividale but at Burnt-tree and Tipton, as also at Oldbury, in which last two places a small coal called Pennycoal, about a foot thick, is sometimes found in them. Their thickness there is from 7 to 20 feet. I do not know how far these beds may have extended and been formerly worked for ironstone in the central portion of the coal-field between Dudley and Bilston, but they are now principally, if not solely, gotten in its south-western portion between Dudley and Stourbridge, especially in the district around Corbyn's Hall and Brierley Hill, where they sometimes together attain a thickness of 27 feet; and at Wordesley Bank Colliery (Vertical Sections, sheet 18, No. 35) the Pins are 4 feet, and the Pennyearth 27 feet thick. They always occur also in the Corngreaves district, where they vary in thickness from 6 feet to 17 feet. It appears that the two measures not always distinctly recognizable, as sometimes one sometimes the other only is mentioned; and moreover, that the presence of good ironstone is uncertain, so that in some instances where the measures exist they are not worth working, and therefore but little noticed. They are not mentioned at all in the sections of Holbeche Mill and the Oak-farm on the one side, nor at

coal. Historically, I believe this was not the fact, as the first working seems to have been along the crop of the Thick coal. I venture to conjecture that the name is derived from the old-used word "broche," a spit, as this coal makes an excellent fire for roasting at.

Netherend near Cradley on the other side of the south-western district; nor do I find them mentioned by name in the sections about Highfields and Bradley south of Bilston, nor in those of Great Bridge and the Swan towards West Bromwich. In some sections, however, as in the old one of Bradley mine, beds containing ironstone are mentioned as occurring a short distance below the Brooch coal, which are probably these measures.

10. ***Intermediate measures, containing the Thick-coal rock.***—These measures, according to the details given in thirty-five pit sections, vary greatly, not only in widely separated parts of the coal-field, but often in places immediately adjacent to each other.

In part of the country just south of Bilston the question is complicated by the occurrence of the "Flying reed," which will be described presently. Supposing this Flying reed to be the top beds of the Thick coal, we have here only 90 feet between it and the Brooch, occupied entirely by "blue binds," while in the beds interposed between the Flying reed and the remainder of the Thick coal there occurs a rock or sandstone of considerable thickness. In the district east of Kingswinford, where the phenomenon of the Flying reed again occurs, we have the recurrence of similar facts.

Setting those exceptional cases aside, we have at Bradley about 60 feet of beds between the Brooch and Thick coals, of which the uppermost portion is clunch and rock binds, with ironstone, the lower, peldon and grey rock, 27 feet thick; while around Tipton, Burnt-tree, Tividale, Great Bridge, Oldbury, and West Bromwich, there is an average thickness of between 120 and 130 feet for these beds, the greatest thickness being 170 feet and the least 83 feet. Of this thickness 75 feet on an average is composed of "rock" or sandstone, the greatest amount of that material being 120 feet and the least not more than 20 feet. The method of its occurrence varies as much as its amount, as it is interstratified with more or less argillaceous materials in every possible way, except that the sandstone seems most generally to preponderate in the lower part of the mass.

In the south-western portion of the district the thickness of these beds also varies considerably. In the mines around Pensnett, Corbyns Hall, and Shut End, their total thickness varies from* 52 feet to 116 feet, the average being 85 feet. In those around Corngreaves (or between the Lye Waste and Rowley Regis) the least thickness is 109 feet, the average rising to 125 feet, while the greatest I know is 157 feet. Around Brierley Hill, on the contrary, and at Wordesley Bank and the Black Delph, the greatest thickness of these beds is diminished to 52 feet, they are sometimes as little as 38 feet, the mean being only 46 feet. In each of these cases the thickness seems to vary almost directly as the quantity of "rock" or sandstone. In the Congreaves district the whole of these beds are almost entirely composed of rock and rock binds. Around Brierley Hill there is not more than 6 feet to 12 feet of rock, while round Corbyns Hall the quantity of rock is generally about half the whole mass, being more or less interstratified with beds of binds or clunch, which are generally described as "strong," meaning that the argillaceous is largely mingled with arenaceous or siliceous material. I do not know that any of these beds have acquired distinctive names, except that occasionally I have found near the bottom of them mention made of "Shooter's four measures," or "Shooter's greys."

* Still exclusive of those mines in which the Flying reed occurs, when the thickness sometimes diminishes to 29 feet.

11. (*I.* 3.) ***Broad earth, Catch earth, and Batt, containing the Ten-foot and Backstone ironstones in the Pensnett district.***—I do not know why the first is called "broad"; "catch" earth, I presume, is so-called because immediately under it they catch the coal, but I have sometimes seen it written "cat earth," or rather "cat heath." These are beds known to the miners, and to them only, as they can only be seen while a shaft is being sunk, and then only just while it is passing through them. They are, I believe, earthy shales of a peculiar character. I have had them described to me as "clunchy stuff," and in other similar terms. They do not appear to be always present, or if so their presence is not always noted in the sections. Where they do occur, however, they are said to be always recognizable by their peculiar character. The total thickness of all three beds seems never to exceed 12 or 14 feet, the most usual numbers being 6 or 8. The "black batt," or hard bituminous shale, is generally about one foot thick, and rests directly on the upper surface of the coal; this seems to be almost invariably present even when there is no mention made of either of the other two beds. In the neighbourhood of Brierley Hill, and some other places, beds in this position, if not these beds, contain ironstone, the lowermost of which is called Backstone, and is found in shale immediately above the coal. The other is called Ten-foot stone, from its being found at that distance above the top of the Thick coal.

In the old Tividale section, mentioned before, the beds immediately above the Thick coal are as follows:—

	FT.	IN.
a Clunch and ironstone - -	2	9
b Black batt - - -	6	0
c Coal - - - -	0	6
d Catch earth - - -	2	9
e Batt - - - -	7	0
f Thick coal - - -	31	6

In a section at Great Bridge, communicated by Mr. W. Matthews, I find these beds:—

	FT.	IN.
a Coal and batt - - -	15	0
b Blue rock - - -	16	0
c Thick coal - - -	32	0

a and *b* being the most anomalous beds to rest on the Thick coal of which I have seen any account.

12. (II. to XV.) THE THICK COAL.—We come now to the description of a set of beds of high interest and importance both to the practical miner and the theoretical geologist. To the latter the careful study of these beds would, I believe, afford many materials for arriving at a better understanding of the question of the origin of coal in general than he now possesses. Some of these materials I may be enabled to lay before him.

The "Thick coal" consists of a number of beds of coal, varying from 8 or 10 to 13 or 14, resting either directly one upon the other or separated by thin seams of "shale," or "clunch," called "partings." Each of these beds of coal is known to the miners by a particular name, and each has so much of a peculiar character that a block of it can be at once recognized by an old "thick-coal collier," and referred to its particular bed. This peculiarity of character in the different beds seems to extend over the whole of the Thick coal district, but whether the beds retain their peculiarities where they cease to form the Thick coal I am not aware. It would be a curious experiment for any one prac-

tically acquainted with the Thick coal to see whether any of the beds of Essington or Wyrley could be identified with any of those of the Thick coal by their lithological characters.

As good typical sections of the "Thick coal" I will, first of all, give two, taken from the central part of the district, one of the Claycroft colliery, at the Foxyards, about two miles north of Dudley, communicated by Mr. R. Smith from Lord Ward's office; another, the old sinking in 1797, at Tividale, one mile east of Dudley, taken from Shaw's History of Staffordshire, in which a very good account of the coal-field was given by Mr. Keir.

Foxyards.	Ft.	In.	Ft.	In.
1. Roofs coal	-	-	4	6
Batt	0	9	–	
2. Top slipper	-	-	2	6
Batt	0	7	–	
3. White coal	-	-	3	9
4. Tow* (tough) coal	-	-	4	6
5. Brassils‡ coal	-	-	1	6
Batt	0	3	–	
6. Foot coal	-	-	2	0
Batt	0	3	–	
7. Slips coal	-	-	3	9
Hard stone	0	7	–	
8. Stone coal	-	-	4	6
9. Sawyer§	-	-	2	9
10. Slipper	-	-	3	9
Batt	0	6	–	
11. Benches‖ coal	-	-	3	0
	2	11	36	6
Total, with partings	-	-	39	5

Tividale.	Ft.	In.	Ft.	In.
1. Roof, or top floor	-	-	4	0
Parting, soft dark earth	0	4	–	
2. Top slipper, or Spires	-	-	2	2
3. Jays coal	-	-	2	0
White stone parting	0	1	–	
4. Lambs coal	-	-	1	0
5. Tow (tough) or Heath	-	-	1	6
6. Benches† coal	-	-	1	6
7. Brassils or Corns coal	-	-	1	6
Foot coal parting	0	4	–	
8. Foot coal, or Bottom slipper	-	-	1	8
John coal parting	0	1	–	
9. John coal, or Slips, or Veins	-	-	3	0
Hard stone	0	10	–	
10. Stone coal, or Long coal	-	-	4	0
11. Sawyer, or Springs	-	-	1	6
12. Slipper	-	-	2	6
Humphrey parting	0	1	–	
13. Humphreys coal	-	-	2	3
	1	9	28	7
Total, with partings	-	-	30	4

A few years ago the unusually thick coal at Foxyards was worked by "open work," as it there "cropped out" to the surface, and was got out from a large quarry, exposing a cliff of coal 40 feet high and about 100 yards in length.

In Shaw's History of Staffordshire Mr. Keir gives the following account of the qualities of the different beds of the Thick coal near Tividale :—

"There is a considerable difference in the quality of the different beds or measures of the main coal. The first or upper bed called the Roof floor is generally left as a roof to support the earth or clunch above

* Pronounced to rhyme with "cow."

† This coal is but rarely noted; there is in many sections a coal called "fine floors," between the "white coal" and the "tow or heath."

‡ "Brassil" is a term generally used to denote a rough impure coal; sometimes it seems as if used to denote the presence of much iron pyrites, and to mean therefore "brassy"; it is not, however, always used in that sense.

§ There is very frequently another coal called "Patchells," especially on the west of Dudley over the Sawyer.

‖ This lowest coal is known by the various terms of Humphreys or Omfray floor, benches, holers, kit, kid, or kick coal, and red coal.

it from falling. The second bed, called the Top Slipper, and the third and fourth beds, which together are called the White coal, are reckoned the best for chamber fires. Next to them in goodness are reckoned the eleventh and twelfth beds, called Sawyer and Slipper. After them come the eighth, ninth, and tenth, called the Foot coal, Stone coal, and John coal. The Tows and Benches are preferred for making the cokes with which iron ore is smelted, and therefore are generally reserved for the furnaces. They do not kindle a flame so vividly as some of the foregoing measures, but they give a more durable and stronger heat. These two measures contain the largest proportion of fibres resembling charcoal. The part of the Brassil measure which contains pyrites is generally laid aside, or used only for burning bricks or lime. The Humphries, being the lowest measure, is that which is cut away in order to let those above it fall down, and, therefore, most of it is reduced to the small coal called sleck."

Proceeding from this central portion of the district, in every direction, we find several minor changes taking place in the constitution of the Thick coal. The individual beds, even where they are all present, vary frequently in thickness, and often in quality, in such a way, however, as to maintain the mean aggregate thickness of 30 feet over by far the greater portion of the district.

There are much more remarkable variations to be now noticed. In by far the larger portion of the extent of the Thick coal we find the upper beds consisting of—

1. Roofs, varying from 2 to 4 feet.
2. Top slipper or spires, varying from 2 to 3 feet.
3. White coal, generally about 3 feet.

Or sometimes the "Roofs" only is mentioned above the "White coal," with a thickness of 3 or 4 feet. If, however, leaving the central part near Dudley, we go towards the district between Bilston and Wolverhampton, we shall find the "White coal" forming the upper bed of the "Thick coal," and we shall get above it a separate bed of coal more or less removed from the "Thick coal," under the name of the "Flying reed coal." At Deepfields, near Coseley, we get the following section :*—

	FT.	IN.	
Flying reed coal - - -	4	0	
Blue binds - - -	54	0	84 feet.
Rock - - - -	30	0	
White coal - - -	3	0	

under which come the "Tow," "Brassil," and the other measures of the Thick coal.

At Highfields, nearer Bilston, we have† (Vertical Sections, sheet 26, No. 51)—

	FT.	IN.	
Flying reed coal - - -	3	6	
Sundries - - - -	54	0	
Do. - - - -	30	0	204 ft. 3 in.
Do. - - - -	89	11	
Rock - - - -	30	4	
White coal - - -	3	0	
Tow coal - - - -	2	0	
&c. &c.	&c.		

* Taken from the "Miner's Guide," published by Mr. T. Smith.
† From Smith's "Miner's Guide."

We thus get the top beds of the Thick coal separated from the rest by 84 feet in one case, and 204 ft. 3 in. in the other; the interposed materials consisting of clay and sandstone. North of Highfield there is no mention at all of the Flying reed, it having either cropped out altogether, or been thrown out by the great Lanesfield fault.

Between Bilston and Wolverhampton, the "White coal" is always looked on as the top of the Thick coal. Here, however, we get still another change in the *central* part of the Thick coal, as a considerable mass of shale, sometimes containing ironstone, is interposed between the "Foot coal" and the "Slips coal."* This mass of shale, which goes by the euphonious appellation of "Hob and Jack," is 7 feet thick at Bradley Lodge just south of Bilston, and 10 feet at the Walling pits near Stow Heath, and at Ettingshall Lodge Colliery. There is exhibited in these facts that tendency in the Thick coal to split up towards the north, which has been already commented on in the general description of the Coal-measures.

If now we proceed from the neighbourhood of Dudley towards the west, we meet with very similar facts.

In going from Dudley to Kingswinford we find the Thick coal preserving a great uniformity of character for nearly three miles, varying but little from the following section :—

SECTION in the Horse-pasture, Corbyn's Hall.†

	FT.	IN.	FT.	IN.
1. Roofs coal - -		-	3	2
White coal parting‡ -	3	6	-	
2. White coal - -		-	3	9
3. Floors coal and batt -		-	1	6
4. Heath or tow coal -		-	3	6
5. Brassils coal - -		-	1	6
6. Fine coal - - -		-	2	6
7. Veins coal - -		-	1	6
Stone coal parting -	0	8	-	
8. Stone coal - -		-	3	0
9. Patchell's coal - -		-	1	0
10. Sawyer coal - -		-	2	0
12. Slipper coal - -			3	0
12. Benches or kid coal -		-	2	5
	4	2	28	10
Total, with partings -	-	-	33	0

A little north of Corbyns Hall, namely, at Shut End Colliery, and thence towards Kingswinford on the west, and Oak-farm on the north, we find a recurrence of the phenomenon of the "Flying reed" similar to that just noticed towards Bilston and Wolverhampton.

At the Dairy-pit in Shut End Colliery we have the Flying reed coal 4 feet thick, resting directly on the White coal 3 feet thick, with the remainder of the Thick coal beneath it, forming a total thickness of solid coal 29 feet 4 inches, with only one 3-inch parting above the

* See Vertical section, sheet 17, comparative sections of Thick coal at the bottom of the sheet, and sheet 18, No. 32.

† Supplied by Mr. W. Matthews.

‡ In other places, however, as at Dudley Woodside, &c., this "white coal parting" does not exist, and No. 1 rests directly on No. 2.

"stone coal." Proceeding to No. 5 pit, about 100 yards south of the Dairy-pit, we get—

	FT.	IN.	FT.	IN.
Flying reed coal			4	0
Soft shaly parting	10	6		
Thick coal			25	4
	10	6	29	4

All the coals having exactly the same thickness as at the Dairy-pit, but 10½ feet of shale being interposed between the first and second. About 120 yards west-south-west of No. 5 pit we get at the new Engine pit—*

	FT.	IN.	FT.	IN.
Flying reed coal			4	8
Strong binds	5	4		
Dark clunch	2	3		
Mild clunch	24	8		
Dark shady clunch	6	6		
Thick coal			22	6
	45	9	26	2

And at another pit 60 yards farther from No. 5, in the same straight line, we have—

	FT.	IN.	FT.	IN.
Flying reed coal			4	4
Mild clunch	29	2		
Dark shady clunch	26	2		
Thick coal			24	3
	55	4	28	7

At Kingswinford, half a mile farther west, we get†—

	FT.	IN.	FT.	IN.
Flying reed coal			3	0
Sundry measures	128	0		
‡ Thick coal			22	8
	128	0	25	8

While at Oak-farm Colliery, about half a mile north-north-west of Shut End, we have §—

	FT.	IN.	FT.	IN.
Flying reed coal			2	6
Strong binds	67	0		
Rock (sandstone)	51	0		
Thick coal			24	0
	118	0	26	6

* The details of the Shut End Colliery were supplied to me by Mr. Colly, ground bailiff to Mr. Foster.

† From Lord Ward's office.

‡ This Thick coal has many small partings between its beds.

§ Supplied by Mr. Growcott, ground bailiff.

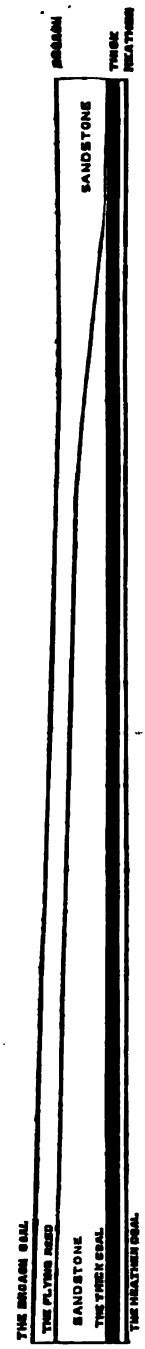


Fig. 4.

The facts stated above are represented in Figure No. 4, in which the original relative positions of the coals are drawn with as close an approximation to accuracy as the materials will allow.

At two pits, sunk since the first edition of this Memoir was published, of which the sections have been communicated by Mr. Beckett, of Wolverhampton, who obtained them from Mr. Growcott, the following facts are noticeable :—

No. 1. Round Hill pits, near Fir Tree House,* Himley,—

	FT.	IN.	FT.	IN.
Flying reed coal - -		-	2	3
Fire clay, &c. - -	8	3	–	
Strong dark binds -	29	0	–	
Binds and peldon -	25	3	–	
Rock and peldon -	46	6	–	
Thick coal (with partings) -		-	39	2
	109	0	41	5

No. 3. Pit of Himley Colliery, a little south of the pit above,—

	FT.	IN.	FT.	IN.
Flying reed coal - -		-	2	6
Fire clay - -	5	0	–	
Rock binds and peldon -	110	6	–	
Thick coal - -		-	24	6
	115	6	27	0

It is very remarkable that there seems to be no corresponding addition to the height of the Brooch coal above the remainder of the Thick coal in these cases ; but as the thickness between the Flying reed coal and the remainder of the Thick coal increases, that between the Flying reed and the Brooch diminishes in nearly the same ratio. Where, for instance, the Flying reed is only 10 feet 6 inches above the rest of the Thick coal, the Brooch is 95 feet above the Flying reed, but it is only 30 feet above it in the last section given above, where the latter is 115 feet above the rest of the Thick coal.

It is farther remarkable that both on the north and on the west where this Flying reed makes it appearance there is a simultaneous change, not only in the grouping, but in the nature of the beds between the Brooch and it. Wherever the Thick coal remains entire, there is a sandstone known as the Thick-coal rock above the Thick coal and between it and the Brooch. When, however, the Flying reed has attained any height above the Thick coal, there is no sandstone between it and the Brooch, but sandstone (or rock) is found underneath the Flying reed between it and the rest of the Thick coal.

It appears, then, notwithstanding the inclined position of the

* See Vertical Section, No. 48, sheet 26.

Flying reed with respect to the Thick coal, that the Brooch remains nearly parallel to the latter, so that we have the three principal coals, the Heathen, the Thick, and the Brooch, retaining their parallelism, while the Flying reed or top part of the Thick lies obliquely between them, separating from each other two similar groups of sandstone beds, one above it and the other below it, these sandstones being nearly on the same horizon, but clearly not contemporaneous with each other.

To the south of the Shut End and Kingswinford district, the measures rapidly resume their normal condition, as represented in the Corbyns Hall section given above. That section may be taken as a sufficiently close description of the Thick coal over all the district between Kingswinford, Dudley, and Halesowen, allowance being made for frequent slight variations in the thicknesses of the different beds of coal and of the partings between them.

As we go down to the Lye Waste, however, near Stourbridge, and approach the south-western boundary of the coal-field, we find a very remarkable change takes place in the character of the Thick coal in that direction, as it loses all its generally distinctive features and assumes those of the following section taken at Tintam Abbey fire-clay works :*—

	FT.	IN.	FT.	IN.
1. Top coal			7	0
Spoil (shale, &c.)	5	0		
2. Middle coal			6	0
Spoil (shale, &c.)	5	0		
3. Bottom coal			6	0
	10	0	19	0
Total, with partings			29	0

Here, then, as before, we find a tendency in the Thick coal to split up into several groups of beds, although here that tendency is produced by a thinning and diminution in the coal itself, and its replacement by earthy beds, and not as before by a mere separation of the beds by additional beds of shale or sandstone.

About a mile to the eastward of Tintam Abbey, at the Hayes colliery, the Thick coal was found to have the following section, communicated by Mr. T. King Harrison, who also informed me, that farther south the coal became so bad and rubbishy as not to be worth working.

Section of the Thick coal at the Hayes colliery, near Lye Waste :—

	FT.	IN.	FT.	IN.
1. Six inch coal			0	5
2. Roofs coal			2	0
3. Spires coal			3	0
4. White coal			3	6
Dirt	2	0		
5. Heath coal			4	0
Dirt	5	0		
6. Brassils			4	0
Dirt	4	0		
7. Fine coal			3	0
8. Stone coal			1	0
9. Foot coal			1	6
Dirt	1	0		

* Supplied by Mr. Skidmore, of Amblecote.

	FT.	IN.	FT.	IN.
10. Patchells coal - -		-	2	6
Dirt - - -	1	0	-	
11. Sawyer coal - -		-	2	3
Dirt - - -	5	0	-	
12. Slipper - - -		-	3	0
	18	0	30	3
Total, with partings - -			48	3

From the frequently high inclination of the beds at the Hayes, it is possible that some deduction must be made from the thicknesses given above, so as to bring them more in accordance with the thickness found in other pits in the neighbourhood. Still the section is good so far as showing the separation of the coals, in which it agrees with the section of the pits at the Hawn colliery, which are the farthest pits towards the south-east that have been opened. It will be seen that at the Hawn colliery the Benches coal is only 6 inches thick, while that bed is absent altogether at the Hayes, where, however, its absence is compensated for by the appearance of a little six inch coal, above the ordinary Roof coal.

The Hawn Colliery.*

	FT.	IN.	FT.	IN.
1. Roof coal - - -		-	1	6
2. Spires, or spin coal -		-	2	7
3. White coal - -		-	3	0
Parting - - -	2	0	-	
4. Heath or tow coal -		-	3	0
5. Brassils coal - -		-	1	6
Parting - - -	3	0	-	
6. Stone coal - - -		-	3	0
Parting - - -	1	0	-	
7. Patchells coal - -		-	1	6
Parting - - -	0	8	-	
8. Sawyer coal - -		-	1	6
9. Slipper coal - -		-	3	0
Parting - - -	1	6	-	
10. Benches coal - -		-	0	6
	8	2	21	1
Total, with partings -		-	29	3

A very similar section to this, except that the partings are hardly so large, is that of Mr. Mills's colliery, about one mile north-by-east of Hawn, just under the "B." of "Black Heath," in the Ordnance map. Mr. Mills gave it me as follows:—

	FT.	IN.	FT.	IN.
1. Roofs coal - -		-	1	6
2. Spires coal - -		-	2	9
3. White coal - -		-	3	0
Parting - -	0	9	-	

* Communicated by Mr. T. A. Attwood.

	FT.	IN.	FT.	IN.
4. Fine floors coal - -		-	1	4
5. Tow coal - -		-	3	0
6. Brassils coal -		-	1	6
Parting - -	0	6		-
7. Fine coal - -		-	2	9
Parting - -	2	0		-
8. Veins coal - -		-	2	0
9. Stone coal - -		-	3	0
Dunjack, hard parting -	0	6		-
10. Patchells coal - -		-	2	9
Batt - - -	0	4		-
11. Sawyer coal - -		-	1	4
12. Slipper coal - -		-	4	3
13. Benches coal - -		-	1	6
	4	1	30	8
Total, with parting -		-	34	9

Now, about three quarters of a mile east-south-east of the latter place, there was a deep pit sunk some years ago by the Rev. E. Dudley, and the place was called the Black Heath colliery. The section of this pit was communicated to me by Mr. Benjamin Gibbons, of Shut End House, and is drawn in the 18th sheet of Vertical sections, No. 23. In this section they found the beds above the Thick coal in regular order, but thin and poor, the Brooch coal, for instance, being not more than 9 inches or 1 foot thick, instead of 3 or 4 feet. They passed through the Broad earth and Catch earth, the usual measures above the Thick coal, but below them they found—

	FT.	IN.
1. Soft parting - - -	1	0
2. Black batt - - -	6	0
3. Bad and rubbishy coal -	7	5
4. Good coal - - -	3	0
5. Brown batt and rock - -	10	0
6. Ditto, with ironstone balls -	4	3
7. Batt - - - -	0	9
8. Coal - - - -	2	0

Of this section 3 and 4 must be taken to represent the Thick coal, 6 the Gubbin measures, and 7 and 8 the Heathen coal, hereafter to be described. Mr. W. Matthews informed me that he drove out gate-roads and headings towards Cakemoor in various directions and for considerable distances from this shaft without being able to find anything of more value or importance. We have here, then, the appearance of a great change and deterioration in the Thick coal, as indeed in the productiveness of the whole series, towards the south-east, proceeding from Dudley as a centre. If again we started from the neighbourhood of Oldbury, where the Thick coal beds have their normal character, we should find, as we proceeded to the south, towards this same Blackheath, that there is likewise a gradual thinning out of the Thick coal. At Mr. Chance's, No. 2 pit, between Park House and Titford reservoir, the Thick coal is only 27 feet thick, and it was said, when worked, to have thinned rapidly out towards the great boundary fault on the east, to only 7

feet, and even less.* Again, at Birchy-field colliery, between Portway Hall and Titford reservoir, the Thick coal is only 21 feet thick, the whole number of beds being described as present, but each a little thinner than ordinary; and further south, near Titford reservoir, the Thick coal was said to end altogether, either by gradual thinning or by the interposition of sandstone and shale beds.

At the time when the first edition of this Memoir was published the above was all the intelligence that could be procured as to the south-eastern corner of the coal-field. Several subsequent explorations, however, have been made which I was able partially to examine in 1858.

In the first place, Dr. Percy's workings in the Thick coal at the Grace Mary colliery, on the north slope of the Rowley Hills, near Lye Cross Farm, have been continued towards the south, or towards the ground where the basalt appears at the surface. The Thick coal in that direction was greatly deteriorated, and its value almost altogether destroyed, by two circumstances, first by its place being largely occupied by white sandstone, which was deposited together with it; secondly, by veins of trap having been subsequently intruded into it. The sandstone thus contemporaneously deposited with the Thick coal, or instead of it, is spoken of sometimes as "rock and rig," and sometimes as a "rock fault." It will be presently described under the latter designation. The trap veins will be also described under the head of Igneous rocks.

In the colliery belonging to Messrs. Bagnall, adjacent to Dr. Percy's, similar or even greater deterioration of the Thick coal was said to occur.

In the district south of Portway Hall some pits have recently been sunk for Lord Ward. One of these is at Ramrod Hall, a little east of Rowley Regis, just where the W. of "White Heath Gate" is engraved on the Ordnance map. In this pit the following section was found, as communicated by Mr. Spence:—

	FT.	IN.
†1. Binds, marl, rock, &c. - - -	381	0
2. Coal (Two-foot?) - - - -	1	9
3. Black ground and fire-clay - - -	10	3
4. Brooch coal and batt - - -	1	0
5. Blue binds and sand rocks - - -	124	0
6. Broad earth - - - - -	3	0
7. Black batt - - - - -	1	0
8. Thick coal (mingled with sandstones) -	4	0
9. Gubbin measures and Heathen coal mixed with sandstone) - - - -	5	0
10. Rock and rock binds - - -	16	9
11. White ironstone measures - - -	2	0
12. Binds with a Stinking coal - - -	5	9
	555	6

At a distance of 70 yards to the eastward of this shaft the Thick coal was found instead of 4 feet to be 26 feet thick, but "to contain several layers of thin rock."

* This information was communicated by Mr. Aaron Peacock.

† For whole section, see Vertical Sections, sheet 26, No. 47.

Other shafts have been worked and Thick coal gotten south of Titford reservoir, but it all seems very subject to be more or less deteriorated by interstratified layers and irregular beds and cakes of sandstone. At Messrs. Harper and Moore's pits, at Causeway Green, the Brooch coal was found with a thickness of 2 feet 3 inches, and the Thick coal was found below at a depth of about 170 yards (510 feet) from the surface, lying regularly and horizontally with the following as its general section, as given me by Mr. Green, on the spot.

Causeway Green Colliery, Messrs. Harper and Moore :—

	FT.	IN.	FT.	IN.
1. Roofs coal - -		-	1	8
2. Top slipper coal - -		-	2	0
3. Jay's coal - -		-	2	0
4. Lamb's and Tow coal -		-	4	0
5. Brassils coal - -		-	3	0
6. Top foot coal - -		-	1	4
7. Bottom foot coal - -		-	0	7
Loamy parting - -	2	0	–	
8. Slipper or Slips coal -		-	1	0
9. Stone coal - -		-	2	3
10. Patchell's coal - -		-	1	4
11. Sawyer coal - -		-	4	0
12. Benches - - -		-	2	0
	2	0	25	2
Total with parting -		-	27	2

In one shaft, however, the coal was found to be separated into two by a great cake of sandstone, 60 feet thick, the section being—

	FT.	IN.	FT.	IN.
Upper part of Thick coal -	-	-	19	6
Sandstone - - -	-	60 0	–	
Lower part of Thick coal -	-	-	4	6
			24	0
			84	0

The whole of the coal also, even where it was not separated by large beds of sandstone, was flecked, and veined with it in all directions, little seams of white sandstone, from a quarter of an inch to two or three inches in thickness, occurring here and there throughout the coal. In some places, too, in the gate-roads, a more considerable body of sandstone might be seen either interposed between two coals, or taking the place of one or other of them for a certain distance.

There was little or no mingling, or kneading together, of the two substances in the same mass, but merely a minute interposition of the two, the sandstone even in the thinnest layers being often clear white quartzose sand, while the coal was clear brilliant black, with apparently even less earthy admixture than usual. The deterioration in the commercial value of the coal was not its inferior quality as coal, but the difficulty of getting large coals free from these layers of sandstone,

and the expense that would be incurred in separating the two substances if that were attempted. (See *postea*, p. 50).

All the evidence then at present known goes rather against the value of the coals and ironstones to be found in the corner of the coal-field that lies south of Oldbury, and east of Rowley Regis and Halesowen, for although particular spots may possibly contain workable beds of coal, yet the hitting on those spots must always be a matter of chance, as there seems to be no indications in the general mass of the ground to lead up to them.

North of Oldbury I know of no important variation in the character of the Thick coal, either towards Tipton or Wednesbury, until we return to the district near Bilston, already described.

In the Thick coal worked beneath the Lower red sandstone, or Permian of West Bromwich, the thickness is described as only 27 feet or 28 feet; but it appears to be all solid coal, with none but the most insignificant partings.

Rock faults, swells, rolls, &c.—There are some remarkable peculiarities and irregularities of structure, which, although by no means peculiar to the Thick coal, but occurring now and then in all beds of coal in all coal-fields, are yet so well seen in the Thick coal on account of the scale on which they are exhibited, that it is worth while to take this opportunity of describing them a little more in detail.

One kind of irregularity has been just alluded to, namely, the occurrence of sandstones in the mass of the coal, or in the place of it. This is often spoken of by the miners, under the name of a "rock fault," a term we may use for want of a better, though it is apt to give rise to confusion, unless it be carefully distinguished from the true "fault," a dislocation which is quite independent of the character or quality of the beds.

Rock faults seem to be of two kinds, the one like that described by Mr. Buddle, under the name of "The Horse," as occurring in the Forest of Dean coal-field, which seems to be the result of a partial denudation or wearing away of the coal just subsequent to its formation, the hollow thus eroded being filled with whatever substance it was that was next deposited on the top of the coal. The other kind of rock fault arises from the contemporaneous deposition of sand or silt together with the coal, so that the formation of the two alternated at comparatively short intervals and over a comparatively small space, so that the whole coal incloses cakes, layers, or masses of sandstone of greater or less magnitude, and more or less intermingled with it. These masses may sometimes apparently be so large as over a certain part of the area to exclude the coal altogether, although they dove-tail into it, and are interlaced with it in interstratified layers round the margin of the area.

I never had the opportunity of personally examining an example of the first kind of rock fault. Mr. Aaron Peacock, however, described one to me as occurring a little west of Oldbury, in the Gower pits at the northern foot of the Rowley Hills. According to this description, which was very carefully given, there was a gap in the Thick coal 60 yards wide, and of much greater length. The bed on which the Thick coal rests is there called the "pouncill batt," and he described this as running under the Thick coal and across the gap the whole way with great regularity. The Thick coal was said to end on each side with a smooth slope, and the Broad earth or Cat earth above the coal was described as coming down over this slope, and running along *upon* the

pouncill batt till it met the other slope, when it rose over it on to the top of the coal again. The distance from the point where the Thick coal first began to diminish in thickness to that where it ceased altogether was about 80 yards, which would give a slope of about 7°. The Cat-heath (or earth) above the coal is about 5 feet thick in the neighbourhood, with sandstone over it, varying in thickness from 12 to 30 yards. In some places, however, there is no Cat-earth, and the sandstone rests directly on the coal. Over the above-mentioned gap in the Thick coal the sandstone is thicker than ordinary, and in one place it is 60 yards thick. The face of the slope of coal on each side of the gap was quite smooth, without any intermingling of the Cat-earth or sandstone with the coal. Unfortunately these workings were under water when the country was surveyed, so that it was impossible to verify this description, which I believe to be sufficiently accurate.

Of the second kind of rock fault I had fortunately a good opportunity of examining an example, through the kindness of Mr. George Thompson, who several times accompanied me through the under-ground workings, and gave me every information both there and in his office.

It occurs at the Baremoor colliery, about three miles south of Dudley. The Thick coal is worked all round the neighbourhood with its usual thickness and characters, and at a depth varying from 350 feet to 600 feet below the surface. A little above it is the usual Thick-coal rock or sandstone, rather thicker, perhaps, than it is generally found in other parts of the coal-field. The following section* from the Old Lion colliery, east of Baremoor, represents very closely the usual section found in all the pits about. (See Vertical Sections, sheet 18, No. 22.)

		FT.	IN.
1.	Upper measures	448	4
2.	Two-foot coal	2	3
3.	Batt and coal mixed	3	0
4.	Brooch coal	2	6
5.	Brooch-stone measures	4	10
6.	Herring coal	1	6
7.	Pins and pennyearth	17	2
8.	Cannel coal	0	9
9.	Brown clunch	3	6
10.	Thick-coal rock, composed of rock binds (argillaceous sandstone) and peldon (hard flinty stone)	106	2
11.	Cat-heath (catch-earth)	1	6
12.	Black batt	3	4
13.	Thick coal and partings	31	0
14.	Black batt	2	0
15.	Gubbin ironstone measures	10	6
16.	Heathen coal	3	5
17.	Parting	2	0
18.	Second Heathen coal	3	3
19.	Table batt†	0	10

* Communicated by Charles Small, ground bailiff, and given now instead of the Old Baremoor or Congreaves sections, which have been already published in Murchison's Silurian System.

† The batt, which generally goes by the name of the Table batt, is above the Heathen coal and underneath the Gubbin ironstone, and would lie between Nos. 15 and 16 of this section.

		FT.	IN.
20.	White rock and peldon - - - -	15	9
21.	White ironstone measures - - -	5	4
22.	Cake ironstone measures - - -	3	0
		671	11

Now if with that section we contrast the following one, found in sinking the new Baremoor pit, we shall at once see the whole amount of the change :—

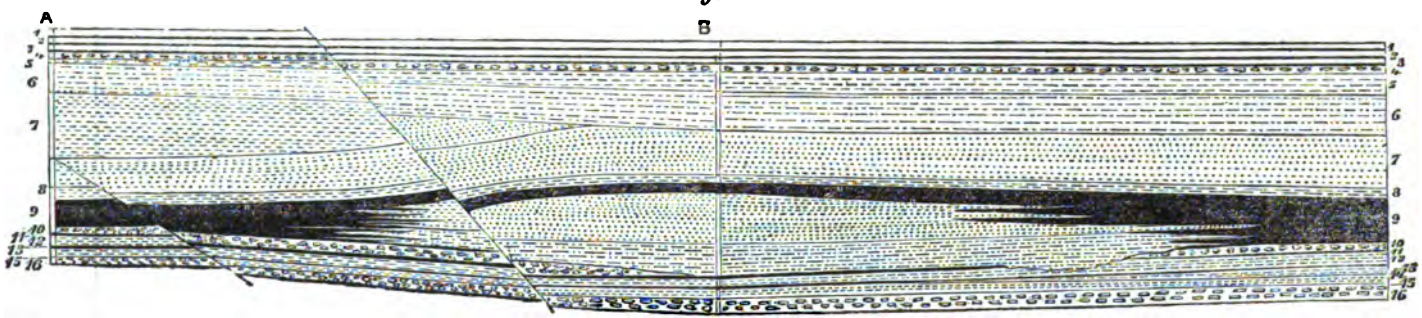
		FT.	IN.
*7.	To the bottom of the Pins and Pennyearth -	280	4
8 & 9.	Heath measures - - - -	15	0
10.	Thick-coal rock, composed of rock binds and sandy rock - - - - -	107	0
11.	Cat heath - - - - -	2	0
12.	Black batt - - - - -	3	0
13.	Top part of thick coal - - -	9	0
	Black batt - - - - -	0	8
	Sandy rock, mixed with clunch - -	42	0
	Rock binds - - - - -	44	8
15 ?	Black batt - - - - -	0	4
16.	Heathen coal - - - - -	2	10
17.	Black batt and fire-clay - - -	5	10
	Brown rock - - - - -	0	10
	Black batt - - - - -	1	0
18.	Second Heathen coal - - - -	3	2
19.	Black batt - - - - -	1	4
20.	Soft brown parting - - - -	0	3
	Peldon and rock mixed - - -	4	0
	Strong white ground - - - -	13	4
21.	Whitestone measures - - - -	6	6
		533	1

Here we find that in this shaft all the measures were regular until they came down into the Thick coal, which, however, they passed through in about 9 feet, and came into sandstone. This 9-foot coal was then worked, and it was said to thin out in every direction by the gradual bending down of its roof, till it was no longer worth following. The shaft having been continued into the Whitestone measures without finding any more Thick coal, and the two Heathen coals having been found lying regularly below, they then proceeded to drive gate-roads (or galleries) from the surrounding excavations in the undiminished Thick coal towards this new Baremoor shaft. In so doing they discovered the nature of the mass of interposed sandstone; and in the year 1849 they had already worked round three sides of it, and thus partially proved its extent.† They found it to be an oval cake of

* I begin with the same numbers as the last section, for the sake of easy reference.

† See Figure No. 5, a section on a true scale of the bottom part of the Baremore shaft, and the adjacent measures.

Fig. 5.



Scale, 1 inch = 133 feet.

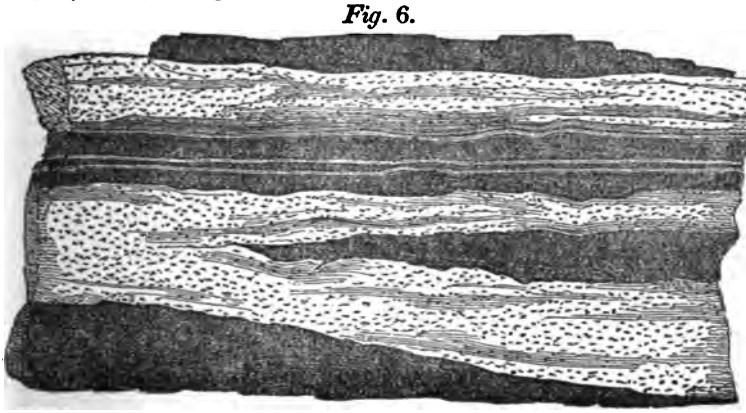
A The Old Baremoor shaft.
B The New Baremoor shaft.

1. The Two-foot coal.
2. The Broach coal.
3. The Herring coal.
4. The Broach binds ironstones.
5. Heath measures.
6. Rock binds, argillaceous sandstone.
7. Rock, sandstone.
8. Cat-heath.
9. The Thick coal.
10. The Grains and Gubbin ironstone.
11. The first Heathen coal.
12. Black batt and fire-clay.
13. Second Heathen coal.
14. Batt and soft ground.
15. Rock, sandstone.
16. Cake and white ironstones.

sandstone, the major axis of which ran nearly due north and south. It was 13 chains or 286 yards wide, and it had been already traced north and south through a space of about 400 yards without reaching its northern extremity. In driving a gate-road towards it in the lowest part of the the Thick coal, it was found that at the height of about 10 feet from the bottom of "the benches," sandstone came in, and formed the roof of the coal; and from that point the sandstone gradually descended, and cut out bed after bed of coal until it reached the bottom of the benches, and some portion of it even descended below the Thick coal, and cut out the upper Heathen coal. When I first visited this gate-road, it was supposed that this sandstone had cut out the whole, not only of the lower part, but also of the upper part of the Thick coal; and the ground bailiff and colliers assured Mr. Thompson that they had bored upwards for several yards, and found nothing but "rock." This, on the subsequent extension of the workings, was proved to be merely one of those falsehoods that these men so frequently assert to save themselves a little trouble. In 1851 the upper part of the Thick coal was found to extend some distance over the extreme point of the interposed sandstone, and there is very little doubt that the 9-foot coal passed through in the New Baremoor shaft, instead of thinning out in every direction, really thickens gradually towards the upper part of the Thick coal around it. What makes this more probable is, that in working from the Thick coal around, towards the shaft, the coal became hard and intractable, making it more difficult to get. It is probable that for this reason the ground bailiff or butty collier, at that time in charge, declared it thinned out, and was not worth following.

This mass of interposed sandstone was very fine grained, rather soft, slightly argillaceous, of a light, greenish white colour; not at all differing from the usual argillaceous sandstones of the neighbourhood, which pass under the name of "rock" or "rock binds." It was not only interstratified with the coal *en masse*, but at or near the junction of the two they each split up into many beds, that interlaced with the utmost regularity. Beds of sandstone, two or three feet thick, extended many yards into the coal, gradually thinning out and splitting up, so that hand specimens could be procured of alternations of bright coal and pale sandstone, each little bed being not more than one tenth of an inch in thickness. Similarly did small beds and thin laminæ of coal stretch into the mass of the sandstone; a few separate masses also, a foot or so in thickness, sometimes occurring suddenly, not as detached fragments, but as little independent beds in the sandstone. Of the alternation and interstratification of the two materials the following cut (Fig. 6) will give a good idea:—

Fig. 6.



D

This figure is taken from a hand specimen, and is three-fourths the natural size. If it were supposed to be indefinitely enlarged till each bed of coal was 2 or 3 feet in thickness, it would do equally well for a representation of the interlacing of the larger beds. It must be borne in mind that even the minute seams of coal in the above-drawn hand specimen were not mere carbonaceous matter, but were perfectly bright, good coal; and that little or no difference was perceived in the quality of the coal interstratified with the rock fault, and that of the same beds in the unaffected coal around it.

It is clear from the above facts that this is not a case of any kind of denudation of the coal subsequently to its formation, but that whatever cause produced this mass of interposed sandstone was acting *during* the time of the formation of the coal. We will, however, defer the consideration of the theoretical inference to be deduced from these cases to a future page.

The occurrence of the "rock and rig" or white sandstone, more or less streaked with coal in the Thick coal at Dr. Percy's pits and the neighbourhood, about a mile to the south-east of Tividale, is one of precisely similar kind to that just described. Great irregularly formed beds of this sandstone come in, over, under, and among the coals there, the coal being sometimes streaked and veined with sandstone layers, and the sandstone having often vein-like layers of perfectly bright coal. In some places there the coal seems to have been partially eroded, and patches of black batt covered by sandstone deposited in the hollows thus formed, in others the two substances were evidently deposited in alternate layers of an inch or two in thickness, the layers of each substance thickening out and coalescing in opposite directions into larger and larger masses.

The whole measures, however, here have been evidently subject to great squeezing and dislocation. They are traversed by faults, and slickenside surfaces are seen in every direction, and sometimes the layers, especially those of coal lying in the sandstone have been bent, and are now tortuous like veins, while masses of the sandstone have likewise indented the coal.

The confusion is further complicated by veins of trap, which are all of a white colour, having intruded into both coal and sandstone, as will be described further on.

Mr. Cooksey, who accompanied me over these workings during the past year (1858), informed me that in driving gate-roads through these masses of intertangled coal, sandstone, and trap, they had met with one or two cakes of unaltered and uninjured Thick coal, of sufficient extent to pay part of the unprofitable outlay in making explorations.*

I also, in October 1858, visited the under-ground workings of Messrs. Harper and Moore's colliery at Causeway Green, accompanied by their agent, Mr. Green. The great cake of sandstone, 60 feet thick, spoken of at p. 44, must undoubtedly be an example of a rock fault. We were not then able to examine it, but in some of the gate-roads I observed masses of sandstone lying in the coal, in so remarkable a manner that I made sketches and measured them as accurately as could be done under ground without greater preparation. These are shown in Figs. 7 and 8.

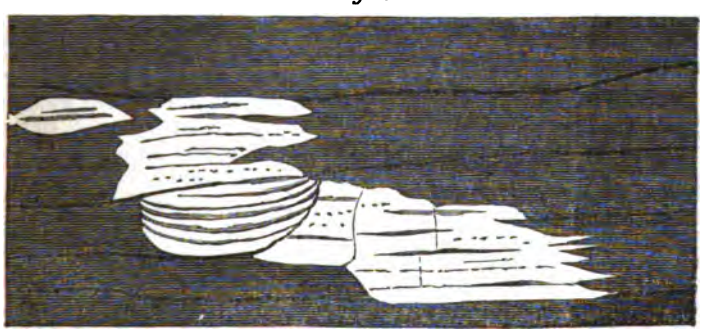
* I have been since informed (July 1859) that they have now driven beyond all this "troubled ground" into good uninjured Thick coal without either sandstone or "white rock" trap.

Fig. 7.

Scale, 8 feet to 1 inch.

The mass of sandstone shown in Fig. 7 was about 18 feet long and 5 or 6 feet high. It was of a pale greenish grey colour, fine grained, principally quartzose, with a little argillaceous matter mingled with it. It occupied parts of four beds of coal, but although laminated throughout and marked here and there with dark carbonaceous streaks, or even little seams of bright coal, it did not seem itself to be separable into four beds, nor was there any distinct plane of stratification (distinct from the lamination) visible in it. Its form was as nearly as possible that given in the sketch, the indentations being as sharp and angular as there drawn. The thinning and arching of the coal over the thickest part of the sandstone was very noticeable.

Fig. 8.



Scale, 4 feet to 1 inch.

Fig. 8 is a similar sketch, taken in a neighbouring part of the same gate-road, drawn on twice the scale. The principal mass of sandstone was about six feet long, with a smaller mass of two feet at one corner. The sandstone extended through three beds of coal, but was more separated by rather irregular planes of stratification than that seen in Fig. 7.

Many other masses of pale sandstone were to be seen in the coal on each side of these gate-roads, while in some places the whole coal seemed mottled and streaked with flakes of sandstones. It was especially remarkable that the thin seams of coal interstratified with these sandstones, seemed even brighter and purer than the main mass of the coal, where it was without any interlacing of arenaceous layers or masses.

Rolls, Swells, &c.—The second peculiarity of structure in the Thick coal is that which forms those irregularities, called "horse's backs," "rolls," "swells," "pack-saddle faults," &c. These are caused by a rise of the floor of a coal up towards the roof, in such a manner as to form a long arched ridge running through the coal, sometimes for a very considerable distance. I examined one of these in the Baremoor colliery, when visiting

Scale, 16 feet to 1 inch.

a Bottom part of Thick coal. 1. Patchells. 2. Sawyer. 3. Slipper. 4. Benches.
b Swell, or horse's back, consisting of dark clunch (black clod). *c*. Large irregular nodules of ironstone.

Fig. 9.—Section of a "swell" in the Baremoor colliery.

it with Mr. Thompson. The black batt containing nodules of ironstone, which usually lies below the coal, seemed to thicken upwards very gradually, and the three lower coals ended against it with a distinctly rounded outline, and without any mark or sign of disturbance, either contemporary or at a subsequent period. So gradual was the rise of the lower batt, that at one part of the gate-road it required 18 feet of horizontal distance to rise 2 feet 9 inches vertically. In other words, the slope was not so much as 1 in 6 (=9°).

Fig. 9 is a sketch of the transverse section of the swell, from a rough drawing and measurement on the spot.

After continuing for a few feet in the Patchells, the crest of the swell gradually descended, letting in the lower coals again, the two sides of it being nearly, if not quite, symmetrical. I do not know what was the longitudinal extension of this particular ridge, but they are often met with one or two hundred yards long; and sometimes one or two will run close together, parallel to each other, for that distance.

It is, of course, possible that they might in some cases have been caused by disturbance anterior to or contemporary with the formation of the lower part of Thick coal, though, in that case, the beds below would be equally bent, which is not, I believe, found to be the fact. It is, however, much more likely that they were merely long ridge-like accumulations of mud or sand piled up in the water in which the measure forming the floor of the coal was deposited. Theoretically, they are important as showing that whatever was the process of the formation of coal, it was in this case necessarily formed in a strictly horizontal position. The lowest bed of the Thick coal (see Figure No. 9) ended against the very gentle slope of the swell, and no bed was formed over it until a sufficient accumulation of coal had taken place around it to make a floor level with its crest. The minute partings of shale or earth between the different beds of coal in the Baremoor colliery sensibly thickened as they approached the swell and coalesced with it.

In a practical point of view these swells are worthy of study, inasmuch as they often diminish or destroy the value of a tract of coal. They very frequently occur, I believe, in all coal-fields, but it is not always that they can be so well examined and understood as in the Thick coal of Staffordshire. They are commonly spoken of by the colliers as faults, a term likely to lead all concerned into great

errors, and which, in a case within my own experience, was the origin of a dispute between two gentlemen in South Staffordshire, involving considerable legal expenses.*

13. (*I.* 4.) ***Pouncill batt, Blacktry and Whitery, containing the "Grains" ironstone, and sometimes the "Whitery" ironstone.***—Immediately under the Thick coal is almost invariably a bed 1 or 2 feet thick of "black batt," dark bituminous shale, which, in the districts immediately east and west of Dudley is called the "Pouncill batt." Under that is from 1 to 3 or 4 feet of dark "ground" or clunch, called "Blacktry." This in the central and southern parts of the fields often contains small nodules of ironstone, called the "Grains ironstone." Under that is 1 or 2 or 3 feet of a light coloured ground or clunch, containing also in some cases ironstone called the "Whitery ironstone." The three beds together never exceed 8 feet in thickness; they are rarely all present at once, the batt seeming the most constant, but they are sometimes altogether wanting, and the Thick coal rests on the measures containing the Gubbin ironstone. In one instance, namely, at Tipton Green, their place is taken by 6 feet of grey rock.

In the Bentley district there is a little coal and ironstone, which, from its position above the top Gubbin, seems to belong to these beds. The following is a section supplied by Mr. James George :—

	FT.	IN.
Ironstone - - - -	0	2
Clunch - - - -	0	10
Batt - - - -	0	5
Ironstone - - - -	0	2
Coal - - - -	1	2
Clunch - - - -	3	0
Clunch and ironstone - -	4	0
	9	9

These measures are there known by the name of the "Bind coal and ironstone."

14. (*I.* 5.) ***The Gubbin or Little Gubbin ironstone.***—This seems to be one of the most constant beds in the whole district. It generally contains ironstone of good quality, and has been greatly worked. The measures usually consist of dark clunch, containing isolated ironstone nodules in one, two, or three bands. Between Bilston and Wolverhampton the measures are from 2 to 4 feet thick, but around Dudley they are generally 6 feet, and sometimes 7, 8, or 9. The following detailed section occurs at Upper Gornal clay-works,† and will give a good idea of the structure of these measures :—

	FT.	IN.	FT.	IN.
Ironstone - - -		-	0	6
Dark clunch -	2	0	–	
Ironstone (cannock) - -		-	0	6
Dark clunch - -	2	0	–	
Ironstone (rubble) - -		-	0	3
Black batt - -	0	6	–	
	4	6	1	3
Total, with partings - -			5	9

* The theoretical and practical importance of these "swells" will be further noticed hereafter (see pp. 190 and 191.)

† Communicated by Mr. Kenyon Blackwell, to whom I must return thanks for much valuable information.

In some parts around Dudley the ironstone of these measures is called "Blackstone," to distinguish it from the "Whitestone," hereafter to be described.

About Bentley this Gubbin ironstone has a little coal associated with it, as in the following section:—

	FT.	IN.
Binds	1	0
Ironstone (Gubbin)	0	6
Binds and batt	1	3
Coal and batt	1	2
Fire-clay	0	10
Coal	0	7
Binds	21	0
Clunch and ironstone	3	0
Black batt	0	11
	29	3

Comparing this section with the one given below from Claycross, it seems probable that the Black batt 11 inches which rests directly on the Heathen coal, is in reality the Table batt, which at Claycross also reposes directly on the Heathen coal.

15. *Table batt and intermediate measures.*—The Table batt is a very compact, black, carbonaceous shale, splitting into large slabs, which when first exposed look firm, but soon crumble to pieces. It is found throughout the southern district with a thickness varying from 2 to 4 feet, except in the neighbourhood of Congreaves, and thence towards Stourbridge and Kingswinford, where I find no mention made of it, and around Corbyns Hall it is only 1 foot thick. Sometimes it has associated with it a little coal and ironstone, as in the section at Claycross, near Dudley, which will be useful for comparison with sections farther north:—

	FT.	IN.
Sharp batt	1	6
Rubble stone	0	5
Little coal	0	6
Brown stone	0	5
Table batt	2	6
	5	4

The measures between the Table batt and the Heathen coal are wholly confined to the district between Walsall and Wolverhampton. We have seen that in the south-western angle of the coal-field the last measure is wanting, and there the Gubbin ironstone measures rest directly on the Heathen coal. Proceeding in every direction from this part, the Table batt comes in between them, at first only a few inches thick, but gradually swelling to 4 feet. Still, in the district around Dudley there is nothing else to be found between the Gubbin and the Heathen coal; but, as we approach Bradley, we get eventually about 10 feet of fire-clay and clunch, and farther north we find a pretty regular thickness of from 18 to 24 feet (or 6 to 8 yards) of clunch, binds, or other argillaceous material, commonly of a white colour, interposed between the black table batt and the heathen coal. Sometimes a "black ring,"* or a small coal 6 or 8 inches thick, makes its appearance

* A "black ring" when mentioned in a pit section means an impure coaly bed, sometimes called "smut," &c.; it forms a black ring round the shaft, whence its name.

in the upper part of these measures, and in the lower part of them there are sometimes ironstone nodules, which are called either Lambstone* or Heathen coal stone.

16, 17, 18. (XVI.) HEATHEN COAL,† *intermediate measures and* (XVII.) RUBBLE COAL.—I take these two coals and their intermediate beds together, because I believe that the Rubble coal of the northern part of the district is the second or Lower Heathen of the southern part.

The Heathen or Upper Heathen coal is a very well marked bed over nearly the whole of the coal-field; it varies from 1½ to 4 feet in thickness; its usual thickness being about 3 feet. Even as far north as the Brown Hills, in the deep pit of the Cathedral colliery, there is a coal which is called Heathen coal, and I believe rightly so called. It has there a thickness of 2 feet 6 inches.

In the district around Congreaves, Cradley, and south of Brierly Hill, there is always mentioned a second or Lower Heathen coal, about 2 feet thick, and from 10 to 20 feet below the first or upper Heathen coal. The beds between the two thicken to the south, and at Mr. King's pits at Netherend are 43 feet thick, chiefly sandstones: they thin out to the north, and about Corbyns Hall, Shut End, and Kingswinford they first of all thin to 1 foot, and then disappear altogether, the two Heathen coals then being considered one coal, and having a thickness of from 5 to 7 feet. Just on either side of Dudley there appears to be neither Lower Heathen nor Rubble coal, but from Tipton northwards around Bilston and thence to Wolverhampton, there is almost always a Rubble coal varying in thickness from 2 to 4 feet, and in depth below the Heathen, from 7 to 24 feet. The interposed materials contain always clunch and other argillaceous matters, and often some sandstone, which occasionally thickens out, and causes the variations in thickness between the two coals. I believe, therefore, that what is called Rubble coal in the district north of Dudley is the same bed with the Lower Heathen coal of the district south-west of Dudley. There is, however, no mention of any Rubble coal beneath the Heathen in the Deepfields sections, nor does it appear to exist in the Bentley district.

19. (*I.* 6.) *Measures between the Heathen and Rubble coals and the New mine ironstone, containing at Bentley the ironstones known there as the Lambstone and Brownstone.*—These beds, in the great majority of instances, wherever they are known, are composed of rock, peldon, and rock binds; that is to say, some variety of sandstone. Sometimes, however, they are said to consist more or less of binds, clunch, or clod, and in a few instances to be entirely composed of those argillaceous materials. Their thickness varies from 10 feet to upwards of 30 feet, the average and by far the most usual thickness being between 15 feet and 20 feet. In some cases, as at Baremoor in the Congreaves district, they contain ironstone, there called "Ballstone," as also at Coseley, Gornal, and in the Chillington field, in which latter place there are two courses of ironstone called "Bindstone."

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* "Lambstone," I am inclined to suppose to be a corruption of "loam stone;" or it is perhaps another form of the same word, and ought to be written "lam."

† This is now the customary orthography of this word in the district. I have, however, seen it written "eathen." The presence or absence of the aspirate is of no account in the matter, as most of the colliers would speak of "a hegg." I believe, therefore, that this term is a corruption of "earthen" as in the case of the "broad heath," &c., mentioned before. Probably the coal when it was first got had an earthy quality or appearance. Mr. Keir, however, writes it "heathing" coal, and it may very well be derived from some obsolete word with which I am not acquainted.

At Bentley the beds next below the Heathen coal are as follows:—

	FT.	IN.
Clunch - - - -	0	10
Clunch and ironstone - -	9	0
Ironstone (Lambstone) - -	0	3
Clunch - - - -	2	6
Black batt - - -	1	0
Ironstone (Brownstone) - -	0	6
Clunch, ironstone, and black batt -	3	3
Other measures, with some ironstones - - -	14	10
New Mine ironstone - -	1	6
	33	8

The ironstone called Brownstone resembles the Black band of Scotland, and is the only ironstone of that quality known in the South Staffordshire coal-field. The Lambstone and Brownstone are not known south of the Great Bentley fault, neither do they range very far to the north of it.

20. (*I.* 7.) *New mine ironstone, or White ironstone.*—This is perhaps the most widely-diffused bed of ironstone in the whole district, as it occurs and is worked from Bentley near Walsall on the north to Hawne near Halesowen on the south. The measures consist almost invariably of clunch, though sometimes they are called clod, or binds; they are always, therefore, of some form of clay; they contain from two to four bands or courses of ironstone, each of which varies from an inch to a foot in thickness. The whole measure is generally 4 feet or 5 feet in thickness, sometimes as little as 2 feet, sometimes, but very rarely, as much as 10 feet.

The following are some details of this measure from different parts of the field:—

Northern part of Bentley estate.

	FT.	IN.	FT.	IN.
Ironstone - -		-	0	3
Clunch - -	0	7	–	
Ironstone - -		-	0	4
Clunch - -	3	3	–	
Ironstone - -		-	0	4
	3	10	0	11
Total with clunch -			4	9

Chillington, near Wolverhampton.

	FT.	IN.	FT.	IN.
Top ironstone -		-	0	3
Clunch - -	3	3	–	
Bottom ironstone		-	1	6
	3	3	1	9
Total with clunch -			5	0

Highfields, near Bilston.

	FT.	IN.	FT.	IN.
Ironstone - -		-	0	3
Clunch - -	1	10	–	
Ironstone - -		-	0	3
Clunch - -	1	10	–	
Ironstone - -		-	0	6
	3	8	1	0
Total with clunch -			4	8

Foxyards, near Dudley.

	FT.	IN.	FT.	IN.
Ironstone - -		-	0	5
Clunch - -	1	6	–	
Ironstone - -		-	0	1
Clunch - -	1	3	–	
Ironstone - -		-	0	3
	2	9	0	4
Total with clunch -			3	6

Gornal Clayworks.

	FT.	IN.	FT.	IN.
White clunch -	1	6	-	
Ironstone - -	-		0	3
White clunch -	2	0	-	
Dark clunch -	1	0	-	
Ironstone - -	-		0	3
	4	6	0	6
Total with clunch -			5	0

Corbyns Hall.

	FT.	IN.	FT.	IN.
Top ironstone -	-		0	9
Clunch - -	5	6	-	
Bottom stone -	-		1	0
	5	6	1	0
Total with clunch -			7	3

Dudley Woodside.

	FT.	IN.	FT.	IN.
Ironstone - -	-		0	2½
Clunch, &c. -	4	0	-	
Ironstone - -	-		0	3½
	4	0	0	6
Total with clunch -			4	6

Around Dudley and to the south-west of it, as also east as far as Oldbury, on the one side, and north to Ettingshall-lane on the other, the most usual name for this measure is White ironstone. Within these limits it is almost the lowest bed from which ironstone is gotten, and is that on which of late years the principal dependence has been placed. To the north-west, around Wednesbury and Bilston, and between Wolverhampton and Walsall, this measure is invariably called New mine stone, and in that district it is one of the uppermost ironstone measures, much richer and more important beds being there found below it.

21. (*I.* 8.) *Intermediate measures containing the Pennystone ironstone, called also the Bluestone and the Cakes.*—These beds are almost invariably dark clunch. They are called sometimes black clod and black ground. They contain sometimes throughout their mass, sometimes only in the lower portion of it, flat roundish nodules of ironstone, generally of a dark colour, and sometimes black, so as to be distinguishable from the New mine Whitestone above them, both in form and colour. The ironstone is sometimes called Blue ironstone, or the Cake ironstone,* as well as Pennystone. South and west of Dudley they rarely contain ironstone, and the whole mass scarcely ever exceeds 5 feet in thickness, being frequently altogether absent, the only exception I know being at the Graveyards near Lower Gornal, where they are described as "Pennystone measure, 18 feet." In the centre of the field between Dudley and Wednesbury ironstone is likewise often absent, as at Tipton Moat colliery, where we have only "dark ground 20 feet." South of that, however, towards Oldbury, ironstone is got from these beds under the name of Cakes or Bluestone; and northwards between Wolverhampton and Walsall, the Pennystone measures are mentioned in nearly all the sections, with a variable thickness of from 10 to 25 feet, sometimes generally, as occupying all the space

* There is a Cake ironstone worked immediately under the Whitestone at the pits round Cradley Heath, &c., which is probably the same as the Cakes east of Dudley.

between the New mine stone and Sulphur coals, sometimes, as at Ettingshall Lodge colliery, in the following form :—

	FT.	IN.
New mine stone, in two measures	3	3
Dark clunch - - -	9	0
Pennystone measures - -	6	0
Sulphur coal - - -	2	6

To the palæontologist it will be interesting to know that* marine shells in considerable abundance occur near Oldbury in the lower part of the New mine stone and the upper part of the Pennystone, like those so well known in the neighbouring coal-field of Shropshire. They are, however, confined to a very small district between Oldbury and Portway. In one mass of ironstone *Lingulæ* were mingled with the common shells called *Unio*,† which are so abundant in many of the ironstones; but it appeared that generally where undoubtedly marine shells were present these so-called *Uniones* were absent. *Lingulæ* are also found in other parts of the coal-field and in lower measures. The *Producta* was observed by me in 1858 as occurring also in considerable abundance in the "White" ironstone between Rowley Regis and High Haden.

22. (XIX.) Sulphur Coal.—This is called as frequently the Stinking coal. It is, I believe, rarely used, on account of its impure and sulphureous qualities. It is, however, mentioned in its proper place in nearly every section we have over the whole district from Hawne, where, with a batt, it is 2 ft. 6 in. thick, up to Bentley and the Brown Hills, where it is generally stated as from 1 foot to 4 feet in thickness. At Coneygree near Dudley it is said to be 6 feet thick; and at Tipton-green the Stinking coal and batt is described as having a thickness of 9 feet. Generally its thickness varies from 2 feet to 4 feet, except around Corbyn Hall and Shut End, where it is often only 2 or 3 inches thick.

At the Cathedral pits in the Rising Sun trough at the Brown Hills, the Sulphur or Stinking coal occurs at a depth of 250 feet, a depth which should bring in the Heathen coal and Thick coal, if the beds in the northern part of the field retained the same structure which they have in the south. The following is an abstract of the section there :—

		FT.	IN.	FT.	IN.
1.	Soil, and clay, sand and gravel -	45	6	81	0
2.	Black and grey clunch - -	35	6		
3.	Coal, believed to be the Bentley Hey coal		-	3	10

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* My late lamented colleague, Professor Edward Forbes, informed me that these fossils are :—

Producta scabricula.
Avicula quadrata.
Pecten (?) unnamed.
Lingula mytiloides (?).
Orbicula nitida.
Conularia quadrisulcata.
Fish teeth and *bones* undetermined.
An *echinus* very much broken up, probably *archæocidaris*, but in too fragmentary a state to be exactly determined.

† Now known as *Anthracosia.*

		FT.	IN.	FT.	IN.
4.	Fire-clay, with small brown ironstone	7	0		
5.	Dark shales and ironstone	2	5	33	8
6.	Dark shales	24	3		
7.	Coal*		-	1	1
8.	Shale, binds, and rock binds	24	10	27	1
9.	Shale, with ironstone†	2	3		
10.	Coal of bad quality†		-	0	6
11.	Bastard fire-clay, with ironstone balls†	9	0	38	4
12.	Dark shales and white rock	29	4		
13.	Coal (Heathen)		-	2	6
14.	Fire-clay and shale	4	6		
15.	Dark shale, with nodules of ironstone‡	6	6		
16.	Ditto, with clay ironstone and brown ironstone‡	2	10	62	0
17.	Light coloured fire-clay, shale and rock binds	24	0		
18.	Dark shale, with measure of ironstone§	16	6		
19.	Dark shale	7	8		
20.	Coal (Sulphur or Stinking)		-	1	8
				251	8‖

The next coal there below this Stinking coal is a coal which we shall afterwards prove to be the top of the New Mine.

There can be little doubt that the beds containing ironstone which come above this Sulphur coal are the representatives of those just described as the Pennystones and New Mine ironstones, and that the coal No. 13 is the true Heathen coal; while the beds numbered 9, 10, and 11 are probably the little Gubbin ironstone and coal, as it makes its appearance at Bentley; and coal No. 7 is the Bind coal which comes in at Bentley with the same thickness, but associated with ironstone.

23. *Beds between the Sulphur and New mine coals.*—In the Priestfield colliery between Bilston and Wolverhampton there is in one pit 99 feet of binds and rock in this position, and in all the adjoining collieries there are 70 feet or 80 feet of the same materials, the sandstone predominating and passing under the name of the New-mine-coal rock, or the Twenty-yard rock. This mass of rock is variably split up with rock-binds and peldon, sometimes with clunch. There is often above it a bed of fire-clay or of clunch a few feet in thickness, supporting the Sulphur coal, but that is frequently absent, and that coal rests directly on the sandstone. Going north towards Bentley the thickness of these measures diminishes to about 30 feet or 40 feet. Going south from Bilston they are still 70 feet at Highfields, consisting of rock and peldon; but at Deepfields there is only 5 feet of fire-clay and 40 of binds, and at Tipton Green but 15 feet of rock, which at Foxyards

* Probably the Binds coal of Bentley.
† Probably the Little Gubbin coal and ironstone.
‡ Probably the New Mine stone.
§ Probably the Pennystone.
‖ For the whole of this section, see Vertical Sections, sheet 26, No. 41.

seems to altogether die out, and 2½ feet of fire-clay alone to interpose between the Sulphur coal and those below it. These great variations in thickness seem to take place principally in the sandstone, which, for instance, about Coseley is only 15 feet thick, while it is more than 60 feet not half a mile off. North of Darlaston, between the Ranters' chapel and Darlaston Forge, the New mine rock, having gradually thinned out from Bilston to a thickness of 9 feet only, suddenly swells out to 78 feet with such rapidity that it was described to me at first as a "fault," by which the Heathen coal and upper measures were thrown up 60 feet or 70 feet.*

The sandstone known as the New-mine-coal rock extends even as far as the Brown Hills where it is known as the Yard-coal rock, the Yard coal being the upper and separated part of the New mine. The rock is there 30 feet thick.

24. (XX.) New mine Coal.—This coal has its normal development in the district between Wolverhampton and Bilston, where it is very regular, and is always 6 or 7 feet in thickness. It is split into two, occasionally, by a thin parting of batt of some 6 or 8 inches. This parting is a little more pronounced at Monmore colliery, north of Willenhall,† where we have the following section :—

	FT.	IN.	FT.	IN.
Coal	-	-	3	9
Batt	1	2	-	-
Coal	-	-	4	6
	1	2	8	3

and about a mile north-east of that, around Bentley, the New mine coal is divided into two by measures which vary from 30 to 50 feet in thickness, composed partly of clay, but principally of sandstone.

These two coals there lose their name of the New mine, and are called respectively the "Yard coal" and the "Five-foot coal," or in some cases the "Four-foot coal," as shown in the following sections :—

Bentley Heath.

	FT.	IN.	FT.	IN.
Yard coal	-	-	3	3
Fire-clay	1	5	-	-
Rock	0	8	-	-
Clunch	3	0	-	-
Rock	35	6	-	-
Five-foot coal	-	-	5	0
	40	7	8	3

Birch Hills Colliery.

	FT.	IN.	FT.	IN.
Yard coal	-	-	3	0
Fire-clay	6	0	-	-
White rock	12	0	-	-
Peldon	6	0	-	-
Rock binds	22	6	-	-
Four-foot coal	-	-	4	0
	46	6	7	0

* I shall hereafter have occasion to remark on the very vague way in which the term "fault" is used in this district, and the patient and skilful cross-examination often necessary to get at its true meaning in the mouth of a collier.

† In this colliery and the neighbourhood is so remarkable an instance of the phenomenon well known to all geologists as "false bedding," or "oblique lamination," that it is worth while describing it. Several small quarries had been opened in some light-coloured sandstone just above the New mine coal, the same as that just spoken of as the Twenty-yard or New-mine-coal rock, and over a space of nearly a quarter of a mile square, the apparent dip of that sandstone was seen in each quarry to be about 25° to the south-east. The sandstone was fine-grained, with *shaly partings*, often

Still farther north, about the Brown Hills, we have the following section :—

	FT.	FT.
Yard coal - - - -	-	- 3
Fire-clay - - -	- 5	–
Rock - - - -	- 40	–
Bass coal - - - -	-	- 6
	45	9

In this part, though only removed a very few miles from the Willenhall and Bentley district, the terms New mine, &c. are entirely unknown, and the identity of the Yard coal and Bass coal with the New mine quite unsuspected* (see Vertical Sections, sheet 26, Nos. 41, 42, 43, and 46).

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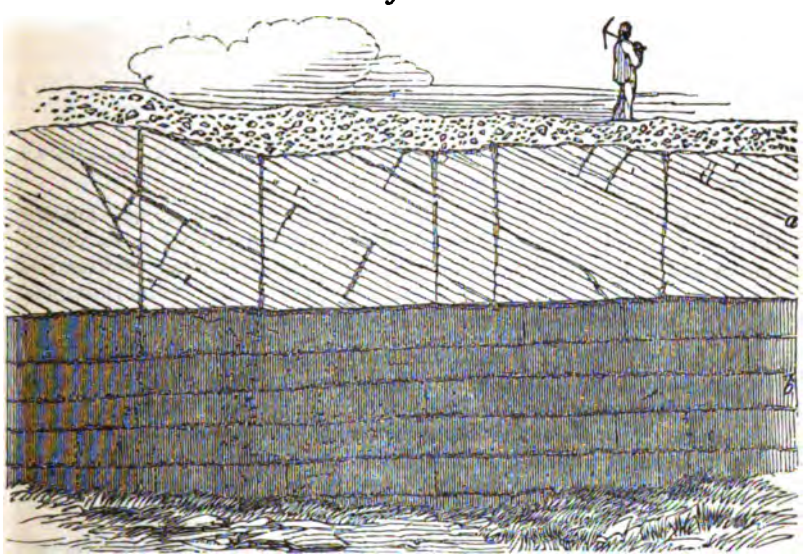
splitting into flags, and the whole of the lines representing stratification inclined at the same amount and in the same direction. As I knew the coal was worked at a very slight depth over all that space, I could not understand why it did not crop to the surface, till I came on a larger quarry that explained the puzzle. In this quarry the coal was seen lying as nearly horizontal as possible, with the shaly and flaggy sandstone dipping regularly down on to it at an angle of 25°.—(See Figure 10.)

Fig. 10.



a Fine-grained flaggy sandstone. *b* New mine coal.

There was no appearance of any lenticular thickening or thinning of the beds of sandstone, they simply ended against the upper surfaces of the coal, which, when bared, was found to be quite smooth, almost as if polished, but not quite level, forming slight undulations, but with no admixture of any other materials than coal. There were, in some places, about 15 feet of sandstone exposed, and about 8 of coal, the length of the quarry being about 50 yards, throughout which there was no material change in this structure. Like other similar structures in most sandy beds, it shows that the materials must have been brought into their present situation by a pretty rapid current, and that a bank being once produced, the successive accumulations were formed on the slope of it into inclined layers or beds.

* The real fact is, that the colliers of each small district neither know anything, nor care to know anything beyond the bounds of their own small locality, and those of Willenhall and the Brown Hills are thus reciprocally ignorant of each other's terms.

It is remarkable that in these and in most other cases of which I have the details, the two coals, though so widely separated, preserve the aggregate thickness of 6 or 7 feet, sometimes increasing to 8 or 9.

If we proceed from Bilston towards the south, we find that between Bilston and Tipton the New mine coal is either divided and increased, or other small coals come in just below it, and are naturally classed with it; for instance, we have the following sections:—

Bilston Meadow.

	FT.	IN.	FT.	IN.
Coal - -			5	0
Parting	1	3		
Coal - -			4	4
Parting	0	4		
Coal - -			4	4
	1	7	11	4
Total with partings			12	11

Highfields.

	FT.	IN.	FT.	IN.
Coal - -			6	0
Parting	2	10		
Coal - -			5	0
	2	10	11	0
Total with partings			13	10

Lower Bradley.

	FT.	IN.	FT.	IN.
Coal - -			5	5
Parting	2	1		
Coal - -			2	0
Parting	0	6		
Coal - -			3	0
	2	7	10	5
Total with partings			13	0

Still further south, however, at Tipton Moat colliery, the New mine coal is only 5 ft. 6 in.; at Tipton Green, 6 ft. 6 in., with a parting; and at Coneygree, near Dudley, 6 ft.

Going thence north-west to the Fox-yards, this coal thins to 4 ft.; and at Upper Gornal clay-works it is only 2 ft. thick.

Similarly to the east, it is only 1 ft. 6 in. at Messrs. Houghton's Whimsey colliery, near Oldbury.

In a cutting of the South Staffordshire Railway, near the Dudley "Castle foot pottery," the New mine and lower coals were distinctly seen cropping out to the surface, with a thickness of several feet, as also in the cutting on the Oxford, Worcester, and Wolverhampton Railway, on the south-west side of Dudley.

Proceeding farther towards the south-west, they appear rapidly to thin out, and finally disappear. A few deep sinkings have been made in this south-western district, in some of which, coals answering, perhaps, to the New mine and those below it, have been passed through, but in so debased a form that it is doubtful whether they are really the same beds, or other little coals occurring here and there near their place.

At the "Graveyard" trial pits, for instance, south of Lower Gornal, below the Sulphur coal, measures were found 22 feet 6 inches thick, consisting partly of clunch and fire-clay, but containing 15 feet of rock; and below them was a coal 1 foot 10 inches thick, believed to be the New mine.

At Upper Gornal clay-works there are 19 feet of measures, containing 7 feet of rock between the Sulphur coal, and the 2 feet of coal which represents the New mine.

Near Corbyns Hall, in three shafts, there was a coal 1 or 2 feet thick, which was from 45 to 60 feet below the Sulphur coal; the intermediate measures having several beds of rock, amounting altogether to upwards of 20 feet.

At Shut End the beds below the Sulphur coal are almost all fire-clay, but 10 or 12 feet of it is described as *gritty*, and at a depth varying from 15 to 30 feet is a small coal 1 foot 6 inches thick.

At the Oak Farm colliery there is a coal 1 foot 6 inches thick, 39 feet below the White stone measures.

At a deep sinking of Mr. Benjamin Gibbons's, at the Level colliery north-east of Brierley Hill, there were found below the Sulphur coal 35 feet of measures, of which 16 were rock; and below these was a small coal 1½ foot thick, which likewise may represent the New mine coal.

At the Ley's iron-works, north-west of Brierley Hill, Mr. Firmstone sank 280 feet below the Thick coal. Below what is probably the Sulphur coal he met with 22 feet of measures, containing 11 feet of rock, when he came on a "rubble" coal 1 foot 2 inches thick, which may perhaps be the New mine.

South of these two places no deep trials were ever made, except in the instance of the Blackheath colliery, south of Rowley Regis; and there nothing was found that could be at all supposed to represent the New mine coal, or any of the beds below it. (See Vertical sections, sheet 17 and 18.)

25. (*I.* 9.) ***Measures between the New mine and Fire-clay coals, containing occasionally the Fire-clay Balls ironstone.***—There is scarcely any group of beds in the whole coal-field which exhibits such rapid and strongly-marked variations as this group. Even in the limited district of the Stow Heath and Priestfield collieries, between Wolverhampton and Bilston, these beds vary from 2 or 3 feet of "binds" to 39 feet of "rock," with a little fire-clay above and below it (Vertical Sections, sheet 16, No. 10). Over the whole district in which the two coals occur, the changes in the beds between them are equally marked, even in closely adjacent localities.*

For instance, at the Chillington colliery they contain only batt and fire-clay, 4 to 9 feet thick; while a mile south of it, at Cockshutts, the beds are—

	FT.	IN.
Clod - - -	5	0
Rock - - -	26	7
Fire-clay - -	3	0
	34	7

At Ettingshall Lodge colliery they have—

	FT.	IN.
Batty fire-clay - -	5	9
Rock and rock-binds -	18	6
Dark clunch - -	3	7
	27	10

While at Ettingshall Lane colliery, one mile south, there are only 2 feet of fire-clay.

* Mr. Lionel Brough, Inspector of Collieries, informs me that at Rose Hill colliery there was only 6 inches between the New Mine and Fireclay coals, the space being occupied by the Fireclay Balls ironstone.

In the central part of the field, south of Bilston, we get the following sections :—

Bradley Lodge.

	FT.	IN.
Fire-clay and batt	4	8
Dark ground	3	0
Fire-clay and ironstone balls	3	9
	11	5

Lower Bradley.

	FT.	IN.
Fire-clay	9	8
Little coal	0	10
Fire-clay	6	0
Rock	3	0
Fire-clay balls, an occasional ironstone	3	0
Dark ground	4	0
	26	6

Around* Highfields, Deepfields, and Tipton collieries there are only 2 to 4 feet of fire-clay, clunch, or binds ; but at Coneygree, near Dudley, these beds again swell out to the following section :—

	FT.	IN.
Fire-clay	2	0
Rock-binds	8	0
Rough rock	3	6
Binds mixed with peldon	4	0
Fire-clay balls ironstone	4	0
Hard rock	3	6
Batt	1	2
	26	2

We will leave the attempt to trace these beds south and west of Dudley till after the description of the Fire-clay coal. Going north from the district already described, (north of Willenhall that is,) we find these beds to have a more constant character than elsewhere, always preserving a thickness of more than 20 feet, and consisting of alternations of rock, fire-clay, and clunch, as the three following sections will show:—

Central Part of Bentley Estate.

	FT.	IN.
Batt, fire-clay, and binds	8	8
Rock	1	4
Binds	7	4
Rock	0	8
Binds and ironstone	4	0
Coal	0	7
Fire-clay and binds	9	0
	31	7

Dudley Brothers Colliery, between Bloxwich and New Invention.

	FT.	IN.
Batt and fire-clay	6	0
Rock binds	17	10
Black batt	0	6
White rock	1	8
Batt	2	0
White rock	3	0
Black batt	1	7
	32	7

(*See Vert. Sects., sh.* 18, *No.* 29.)

Brown Hills Colliery.

Fire-clay	2
Rock	27
	29

* See Vertical Sections, sheet 16, No. 12, and sheet 26, No. 51.

26. (XXI.) FIRE-CLAY COAL.—We will again take the Stow Heath and Priestfield collieries, between Wolverhampton and Bilston, as the typical locality for the description of this coal. It has there an almost invariable thickness of 9 or 10 feet, with or without a "parting;" and at a distance of 1 to 3 feet below it is another small coal called there "the Little coal." The following is the section of a shaft a little east of Stow Heath Furnace:—

	FT.	IN.	FT.	IN.	
Fire-clay coal, top	-	-	6	0	9 feet.
Parting	1	0	-		
Fire-clay coal "holers" *	-	-	3	0	
Slummy batt	2	6	-		
Little coal	-	-	2	6	
	3	6	11	6	

This thickness and arrangement of beds, with some slight variations, seem to prevail through the Chillington, Rough Hills, and Parkfield collieries down to Coseley, and also about Deepfields, Dockmeadow, and Highfields.

In other places, however, both north towards Bentley and south towards Dudley, the Little coal is entirely wanting, and the Fire-clay coal much altered in thickness. In the northern direction we have the following sections (see Vertical Sections, sheet 16, Nos. 6, 11, sheet 26, No. 45):—

Trentham Colliery, between Wednesfield and Willenhall.†

	FT.	IN.	FT.	IN.
Coal	-	-	1	2
Parting	1	0		
Coal	-	-	2	4
Parting	1	0		
Coal	-	-	0	10
	7	0	4	4
Total with parting			6	4

Sandbeds between Willenhall and Bentley.‡

	FT.	IN.	FT.	IN.
Coal	-	-	1	2
Parting	0	9		
Coal	-	-	2	8
	0	9	3	10
Total with parting			4	7

Bentley Heath.‡

	FT.	IN.	FT.	IN.
Coal	-	-	2	1
Fire-clay	0	7		
Coal	-	-	1	2
	0	7	3	3
Total with parting			3	10

On the southern side of Stow Heath we get frequent sudden changes even in spots surrounded by places before mentioned. At Friezeland colliery, for instance, just south of Priestfield, there is only "batt and coal, 2 feet," to represent the Fire-clay coal. At Lower Bradley we have "coal and batt, 5 feet," but at Mr. Addenbrook's colliery at Upper

* "Holers" is a term frequently applied to the lowest of a set of coals which are sufficiently close to be "gotten" together. In getting the coal a low wide hole is excavated by the pick some distance into the bottom bed of coal; the upper beds are then cut on each side of this "hole," and, of course, fall into it.

† Communicated by Messrs. Bate. ‡ Communicated by Mr. George.

Bradley, there is a little coal above instead of below the Fire-clay coal, as follows :—

	FT. IN.	FT. IN.
Coal - - - -	-	0 6
Black batt - - -	5 0	-
Fire-clay coal - -	-	5 4
	5 0	5 10

Similar to this is a section at Tipton Green (Vertical Sections, sheet 16, No. 12), where the only representative of the Fire-clay coal is,—

	FT. IN.	FT. IN.
Coal - - - -	-	0 3
Fire-clay - - -	5 0	-
Coal and batt - -	-	2 6
	5 0	2 9

The section at Tipton Moat is the same, except that the lowest coal is only 10 inches thick. At Gornal clay-works there is simply 2 feet of poor coal ; at Darlaston the same ; and at Dudley Port, 2 feet 6 inches. At the Foxyards, however, we have the two following sections :—

*The Sinking Pit.**

	FT. IN.	FT. IN.
Little coal - -	-	1 6
Fire-clay - -	1 6	-
Coal - - -	-	0 7
Fire-clay - -	2 5	-
Coal - - -	-	2 7
	3 11	4 8
Total with partings -		8 7

Another Pit.†

	FT. IN.	FT. IN.
Coal - - -	-	2 7
Parting - -	1 9	-
Coal - - -	-	1 4
	1 9	3 11
Total with partings -		5 8

If now we pass into the district south and west of Dudley the same remarks will hold good as to the "Fire-clay" that were used respecting the "New mine coal," but to a still greater extent. There are but five shafts of which I have sections, in which any coal near its place is mentioned. Of these one is the Grave-yard Trial pits,‡ south of Gornal, where below what is supposed to be the New mine coal we get,—

	FT. IN.	FT. IN.
Rock and fire-clay - -	5 9	-
Coal (possibly the Fire-clay) -	-	1 8
	5 9	1 8

* Communicated from Lord Ward's office, by Mr. R. Smith.
† From Smith's "Miners' Guide." ‡ Lord Ward's office.

Two shafts near Corbyns Hall give below what is there believed to be the New mine coal:—

	FT.	FT.	FT.
Fire-clay - -	10 to 12		–
Coal - -	-	-	1
		12	1

At Shut End we get below the supposed New mine coal the following beds:—

	FT.	IN.
Gritty and strong fire-clay -	16	4
Coal and batt - - -	1	6
Hard and white rock - -	10	4
Coal - - - -	2	8
	30	10

Which (if either) of these may represent the Fire-clay may be reasonably a matter of doubt (see Vertical Sections, sheet 18, No. 31).

At Mr. Gibbons's deep sinking at the Level near Brierley Hill, there was below the supposed New mine coal,—

	FT.	IN.
Fire-clay - - - -	7	0
Clunch with balls of ironstone -	4	0
Binds - - - -	2	3
Coal and batt, possibly Fire-clay coal	1	6
	14	9

At Mr. Firmstone's deep sinking at the Leys, however, not a trace of coal had been met with below that which we have already designated the New mine, although the sinking was continued for upwards of 77 feet.

27 to 31. (*I.* 10, 11, 12.) ***Measures between the "Fire-clay coal" and the "Bottom coal," including the Getting rock ironstone, the "Poor robin ironstone," and the "Rough Hill White ironstone."*** *

The total thickness of these beds varies commonly from 20 to 30 feet in the district where they are most worked, namely, between Wolverhampton and Walsall. The upper measure is generally fire-clay or clunch, supporting the Fire-clay coal and varying in thickness from 2 to 10 feet. This, however, is sometimes entirely wanting, and the Fire-clay coal rests directly on a "strong rock" or hard sandstone. This rock sometimes contains so much ironstone, either in plates or nodules, as to be worth getting. Beneath this is either more "rock" or else "batt," "clunch," or "binds," several feet in thickness, and then a measure always of argillaceous materials containing either nodules or courses of ironstone, which is the "Poor robin." Immediately beneath this, or sometimes with a few feet of rock, or binds, or clunch interposed, come the Rough Hill White ironstone measures. This ironstone

* By the Getting rock is meant a sandstone which when it contains ironstone is worth getting. I can only refer the origin of the term "Poor robin" to the fantastic imagination of some fanciful collier. The other derives its name from its colour and the locality, the Rough Hills south of Wolverhampton, where it was first worked.

is very local, being only fouund between Darlaston and Wolverhampton in sufficient quantity to be worth working. At Parkfields, south of Wolverhampton, the whole measure is 19 feet 2 inches thick, with 11 bands of ironstone in it, but elsewhere, even when it occurs, it is rarely more than 2 to 4 feet in thickness.

The following are a few selected sections of this group of beds:—

*Bentley.**

	FT.	IN.
Fire-clay	1	4
Clunch and binds	19	4
Rock	4	0
Binds and clunch	12	2
Clunch and ironstone, probably Poor robin	2	8
Whitestone (iron)	4	11
	44	5

Stow Heath.†

	FT.	IN.
Fire-clay	3	0
Slums	3	0
Getting rock	4	0
Black batt	7	6
Poor robin	2	6
Black batt	9	0
Whitestone	2	3
	31	3

Priestfield.‡

	FT.	IN.
Black clod	10	0
Poor robin	4	0
Light clod	7	0
Whitestone	2	6
	23	6

Ettingshall Lodge.§

	FT.	IN.
Getting rock	4	9
Stratified grey rock	1	4
Batt, inflammable	7	7
Poor robin	3	6
Batt, inflammable	5	0
Whitestone	3	6
	25	8

(*Vert. Sects., sheet* 16, *No.* 8.)

Deepfields.‖

	FT.	IN.
Getting rock	5	0
Poor robin	3	3
Whitestone	3	0
Ironstone balls and gubbin	4	9
Fire-clay	10	6
	26	6

Bradley.¶

	FT.	IN.
Fire-clay	6	0
Rock	0	7
Ironstone balls	1	6
Rock binds	12	6
Poor robin	4	11
Black batt	3	11
Whitestone	3	9
	33	4

If we proceed, from the district thus characterised, farther south, we find one or both of the ironstones quickly disappearing, and the total thickness of the beds diminishing sometimes to only 8 feet. At Highfields for instance, although there is still ironstone, the beds between the Fire-clay and Bottom coals are only two measures of clunch, with ironstone balls, each 4 feet thick.

* Communicated by Mr. George.
† Communicated by Mr. Arthur Sparrow.
‡ Communicated by Mr. W. Ward.
§ Communicated by Mr. Griffith of the Cock-shutts.
‖ From the "Miners' Guide."
¶ Communicated by Mr. S. H. Blackwell.

Elsewhere we get the following sections :—

*Lower Bradly.**

	FT.	IN.
Fire-clay	9	0
Getting rock	9	0
Dark ground	17	6
	35	6

Coseley.†

	FT.	IN.
Rock	6	6
Ironstone measures	4	6
Binds	5	6
	16	6

Near Cann Lane.‡

	FT.	IN.
Strong rock	28	0
Black batt	3	0
	31	0

*Near Darlaston.**

	FT.	IN.
Brown bastard fire-clay	10	9
White rock	0	3
Brown clunch	6	0
	17	0

The Foxyards.§

	FT.	IN.
Fire-clay rock	2	0
Dark rock	3	0
Fire-clay balls (Poor robin?)	3	6
Ironstone (Rough Hills White	2	6
	11	0

Tipton Green.‖

	FT.	IN.
Rock	9	5
Rock, with balls of iron stone	1	11
Rock	6	10
	18	2

32. (XXII.) The Bottom Coal.¶—In the part of the coal-field near Wolverhampton, this coal has a pretty uniform thickness of about 12 feet, as in the following section given me by Mr. W. Ward, from a pit a little south of Stow-heath furnace :—

	FT.	IN.	FT.	IN.
**Gainies (inferior coal)	-	-	2	0
Top coal	-	-	5	0
Parting	1	0	—	
Holers coal	-	-	4	0
	1	0	11	0
Total with parting			12	0

This condition of the Bottom coal extends generally from Wolverhampton to Willenhall, Bilston, Darlaston, and Coseley.

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* Communicated by Mr. S. H. Blackwell.
† From the "Miners' Guide."
‡ Communicated by Mr. Grogart.
§ Communicated from Lord Ward's office.
‖ Communicated by Mr. Johnson.
¶ This name, assigned to it at first in one locality, turns out, as is often the case, to be a misnomer, as in other localities there are other coals below it, one of which at least is sometimes worth getting.
** Takes its name, I believe, as the bed by which they first arrive at or gain the coal in sinking a pit.

Outside of those limits, however, the variations in the character of the Bottom coal are many and sometimes come in suddenly. Even within those limits we have the following sections:—

*Parkfield.**

	FT.	IN.	FT.	IN.
Coal			4	9
Parting	0	8		
Holers coal			1	0
	0	8	5	9
Total with partings			6	5

*Ettingshalls Lodge near Catchem's Corner.**

	FT.	IN.	FT.	IN.
Gainies, bad coal			1	6
Parting batt	0	4		
Top coal			5	3
Parting batt	10	0		
Holers coal			4	6
	10	4	11	3
Total with partings			21	7

Dockmeadow, south of Bilston Ironworks.

	FT.	IN.	FT.	IN.
Coal			4	6
Rock	6	0		
Rock binds	3	0		
Ironstone balls	1	0		
Rock binds	4	0		
Coal, believed to be Holers			3	0
	14	0	7	6
Total with other beds			21	6

These three places lie in a straight line about one mile in length, and running nearly west-north-west and east-south-east.

About a mile south of Bilston, at Highfields and Bradley, the Bottom coal is only 3 or 4 feet thick. At Tipton Moat Colliery it is 9 ft. 6 in., from which 2 ft. 6 in. must be deducted for three "parting batts;" at Tipton Green there is said to be "coal and batt," 11ft. 9 in.; and at the Foxyards, 9 or 10 feet of coal. Farther south, however, at Coneygree and Dudley Port, the Bottom coal, if it exist at all, is not more than a foot or so in thickness.

At Shaver's End, just north of Dudley, the following was the section in a trial pit of Lord Ward's:—

	FT.	IN.	FT.	IN.
†Coal			2	0
Parting	0	9		
Coal			2	0
Parting	0	7		
Coal			0	10
Parting	1	0		
Coal			2	10
	2	4	6	10
Total with partings			9	2

* Communicated by Mr. Griffiths.

† Lord Ward's office.

And at Upper Gornal clayworks, the following beds represented the Bottom coal :—

	FT.	IN.	FT.	IN.
*Coal	-	-	1	6
Parting	0	8	-	
Coal	-	-	0	4
Fire-clay	1	2	-	
Coal	-	-	2	0
	1	10	3	10
Total, including partings			5	8

A mile and a half south of this latter locality, at the Graveyards, in what we have spoken of as the south-western part of the coal-field, we get, below the little coal which we have already supposed to be the Fire-clay coal, a set of beds 28 ft. 5 in. in thickness, alternations of fire-clay, rock, clunch, and binds, and containing two "ball ironstone measures," which may perhaps represent the ironstones of the "Poor robin," and "Rough Hill White;" and below these, a coal 2 feet thick, which may probably represent the Bottom coal.

Similarly at Mr. Gibbons's Level colliery, there was found the following section :—

	FT.	IN.	FT.	IN.
1. Coal and batt, supposed Fire-clay	-	-	1	6
2. Fire-clay	6	3		
3. Strong dark clunch, with balls of ironstone	6	5	20	11
4. Strong white rock	4	0		
5. Broad earth, with balls of ironstone	4	3		
6. Coal	-	-	1	0
7. Black batt	0	5	6	1
8. Fire-clay	5	8		
9. Coal and batt	-	-	1	5
			30	11

Of which beds 2 to 5 may represent those described in the last section (Nos. 27 to 31), and either 6 or 9, or the group of 6 to 9 inclusive, may represent the "Bottom coal." These are the only localities in this south-west district in which, so far as I am aware, any beds that can be compared with the Bottom coal of the Wolverhampton district have been met with.

We may now return to Willenhall, and trace the Bottom coal towards the north and east, namely, to Bentley, Bloxwich, and the Brown Hills. At the Trentham colliery, near Mumber-lane, the Bottom coal assumed the following form :—

	FT.	IN.	FT.	IN.
†Coal	-	-	0	11
Parting	0	3	-	
Coal	-	-	0	5
Parting	0	4	-	
Coal	-	-	0	7

* Mr. J. Kenyon Blackwell. † From Messrs. Bate.

	FT.	IN.	FT.	IN.
Parting	0	2	–	
Coal	–	–	4	10
Fire-clay	1	6	–	
Clod and stone	10	0	–	
Rock binds	8	0	–	
Batt	2	0	–	
Holers coal	–	–	4	6
	22	3	11	3

At Monmore colliery, half a mile east of this, there was—

	FT.	IN.	FT.	IN.
Coal	–	–	3	2
Fire-clay	6	9	–	
Rock binds and ironstone	7	8	–	
Fire-clay	18	4	–	
Coal, holers	–	–	3	3
	32	9	6	5

(*See Vertical Sections, sheet* 18, *No.* 30.)

About Bentley the coals close together again with only a little batt between them, but make a total thickness of not more than 7 or 8 feet. This at the Birch Hills becomes 12 or 14 feet, with only 8 inches of batt; and it retains a thickness of 12 feet towards Bloxwich and Goscott.

For the space of a mile or so between the Birch Hills and Goscott this twelve-foot Bottom coal is called by the colliers the Four-yard or Thick coal, because it is thicker than any other coal thereabouts, and not with any reference to the true Thick or Ten-yard coal, of which most of them know very little, though it is worked within five miles of them.

The outcrop of the Bottom coal may be followed continuously from Bentley acros the Great Bentley fault by Ryecroft to Coal Pool, where it was formerly cut into, and in October 1858 might be seen in a large open work running for about 50 yards on the east side of the brook north-east of Goscott Lodge.

This part of the outcrop was cut off to the northward by a fault having a downthrow to the north of about 10 yards, but the coal had been worked formerly up to Pelsall Heath. Just at the southern corner of Pelsall Heath this twelve-foot coal was known from old workings to separate into two coals of 5 feet and 7 feet. This separation was the consequence of the coming in of some beds of shale and sandstone, which rather rapidly increased towards the north till they attained a thickness of 40 or 50 feet. The Bottom coal, thus separated into two, was worked formerly for some distance along the outcrop north of Pelsall Heath, till it was dropped out of reach of the "old men" by downcast faults into that which may now be called the High Bridge trough. The corresponding upcast faults on the north side of this trough brought these coals again near the surface about the Brown Hills, and they were there gotten both by the "old men," and the men of the last and present generation. All the way along these outcrops of the coals, or wherever they came within a sufficiently slight depth of the surface to be easily worked, they received the name of the Shallow coal and the Deep coal (Vertical Sections, sheet 26, Nos. 41, 42, 43, and 46).

The following are a few of the sections that show this northern expanded form of the Bottom coal :—

Messrs. Davis and Bloomer's Pit, No. 3, Pelsall Wood Colliery.

	FT.	IN.	FT.	IN.
Shallow coal - -	-	-	4	0
Fire-clay - -	3	0	–	
Strong clod - -	30	0	–	
Strong rock - -	12	0	–	
Deep coal (roofs) - -	-	-	3	0
Fire-clay - -	2	6	–	
Deep coal - -	-	-	5	0
	47	6	12	0
Total -			59	6

(*See Vertical Sections, sheet* 26, *No.* 43.)

High Bridge Colliery, about a quarter of a mile north-east of "The Moat."

	FT.	IN.	FT.	IN.
Shallow coal - -	-	-	5	2
Fire-clay - -	3	0	–	
Rock binds - -	13	0	–	
Hard grit and peldon -	4	0	–	
White grit rock -	6	0	–	
Rock binds - -	5	9	–	
Hard grit - -	6	0	–	
Deep coal (roof) - -	-	-	1	9
Clod - - -	9	0	–	
Deep coal - - -	-	-	4	7
	46	9	11	6
Total -			58	3

(*See Vertical Sections, sheet* 26, *No.* 46.)

Cathedral Colliery, Brown Hills, just south of 120*th milestone on Watling Street.*

	FT.	IN.	FT.	IN.
Shallow coal - -	-	-	6	0
Fire-clay - -	2	0	–	
Strong blue laminated shale	10	0	–	
Rock binds - -	12	0	–	
Strong rock, with dark shades - - -	6	0	–	
Shale, with ironstone layers	11	3	–	
Deep coal (roof) - -	-	-	0	10
Dark shale - -	3	2	5	0
Deep coal - - -	-	-	5	0
	44	5	11	10
Total -			56	3

(*See Vertical Sections, sheet* 26, *No.* 41.)

Conduit Colliery Brown Hills, north of Watling Street.

	FT.	IN.	FT.	IN.
Shallow coal - -		-	6	0
Bastard fire-clay - -	5	10	–	
Rock binds - -	4	2	–	
Rock, with peldon -	7	7	–	
Rock binds - -	2	9	–	
Rock - - -	2	4	–	
Rock binds - -	25	7	–	
Black batt - -	0	7	–	
Deep coal (roof) - -		-	1	1
Fire-clay - -	3	7	–	
Deep coal - - -		-	5	0
	52	5	12	1
Total -			64	6

(*See Vertical Sections, sheet* 26, *No.* 42.)

Hammerwich Colliery, below the dam of the Reservoir.

	FT.	IN.	FT.	IN.
Coal (shallow) - -		-	7	1
*Warren earth (fire-clay ?)	3	0	–	
Grey leys - -	3	8	–	
Rock binds - -	0	5	–	
Metals (shales) - -	5	7	–	
Rock - - -	4	8	–	
Blue metals - -	0	11	–	
Rock binds - -	0	6	–	
Blue metals - -	3	0	–	
Rock binds - -	0	8	–	
Blue metals - -	1	6	–	
Rock binds - -	0	5	–	
Metals and iron binds -	25	1	–	
Black shale - -	0	6	–	
Coal (roof of deep) - -		-	0	7
Clod - - -	0	6	–	
Coal (deep) - -		-	5	2
	50	4	12	10
Total -			63	2

(*See Vertical Sections, sheet* 16, *No.* 2.)

33. *Measures between the Bottom coal and the Gubbin and Balls ironstone.*—The Bottom coal usually rests on a bed of fire-clay some feet in thickness. In many instances, however, this is wanting, and the coal rests on hard sandstone, the change from one material to the other being sometimes very abrupt. Wherever the Gubbin and Balls ironstone exists, it is found at a distance below the Bottom coal varying from 5 feet to 30 feet, the most usual distance being 15

* Warren earth and some of the other terms used in this section are those common in the Derbyshire, Nottingham, and Yorkshire coal-field.

or 20 feet. The beds between consist sometimes entirely of fire-clay, binds, clunch, or clod, or other argillaceous materials; sometimes these are variously split up by, and interstratified with rock or rock binds, and occasionally these sandy materials almost entirely replace the others. A little coal a few inches thick sometimes occurs in these beds, and the interposed beds of clunch sometimes contain scattered balls or nodules of ironstone.

34. (*I.* 13.) *The Gubbin* and Balls ironstone.*—This set of beds, as a distinct and recognizable measure, containing ironstone worth getting, and regularly "gotten," is chiefly confined to the district around Wolverhampton, Bilston, and Walsall. The following section at Chillington colliery near Wolverhampton gives its best developed form:—

	FT.	IN.	FT.	IN.
Balls of ironstone			0	8
Clod	2	6		
Balls of ironstone			0	6
Dark clod	1	6		
Gubbin ironstone			0	6
Clod	1	0		
Gubbin ironstone			0	3
	5	0	1	11

(*See Vertical Sections, sheet* 16, *No.* 9.)

Measures similar in character, varying from 5 feet to 10 feet, and containing more or less ironstone, sometimes the Balls, sometimes the Gubbin being absent, and sometimes both found wanting, extend all over the district just mentioned. South of Bilston around Bradley they diminish to about 3 feet. At Tipton Moat colliery there is mentioned "binds with ironstone, 8 feet," about the place of the Gubbin and Balls, namely, at 10 feet below the Bottom coal, but at Coneygree, Foxyards, Gornal, Shaver's End, and the neighbourhood of Dudley generally, there seems no trace of this measure.

The sole vague and uncertain trace of them in the south-western district is the mention in the Graveyard section of "ironstone balls 6 inches," at a depth of 5 ft. 6 in. below what is believed to be the Bottom coal.

Going north towards Bentley, we get, at the Island, the following section:—

	FT.	IN.	FT.	IN.
Balls of ironstone			0	3
Clunch	2	0		
Ironstone			0	4
Clunch	1	0		
	3	0	1	0

As the representative of this measure in the central part of the Bentley district, and thence by Birch Hills and Bloxwich, there is only mentioned in the pit sections "gubbin 6 inches."

* I believe this term "Gubbin," which is commonly used in all the Midland coal-fields, is derived from an old English word "gub" or "gob," meaning a piece, lump, or fragment. The waste left after extraction of a coal is called "the gob."

At one part of the Brown Hills, however, near Clayhanger, Samuel Arblaster found under the Deep coal—

	FT.	IN.
Fire-clay and clunch - -	13	6
Gubbinstone, balls of ironstone in two or three layers, and each 6 or 8 inches thick - - -	3	0

At the deep sinking at Haddocks Moor too, near Pelsall Wood, Gubbin ironstone 2 feet 6 inches is mentioned, with 9 feet of Fire-clay between it and the Deep coal, and with a little 6-inch coal immediately under it.

And at the Conduit Colliery at Brown Hills the following beds were found next below the Deep coal :—

	FT.	IN.
Bastard fire-clay - - -	8	0
Black batt - - - -	1	6
Gubbin ironstone measures - -	3	6
Coal - - - - -	0	11

Near Wolverhampton the Gubbin and Balls stone is a very well marked and easily recognizable kind of stone. The large nodules are generally septarian, the septa being lined with white spar, crystals of carbonate of lime and carbonate of iron, together with crystals of iron pyrites, and not unfrequently of both galena and zinc blende.

35. *Beds below the Gubbin and Balls, including* 36. (XXIII.) *the "Singing" or "Mealy-greys" coal.*—Wherever the Gubbin and Balls is mentioned in the sections as a recognizable measure, there is found just below it either a little bed of pure coal 6 or 8 inches thick, or a bed of "slum" (batty coal), which is often 2 or 3 feet thick, and sometimes more. In Cockshutts colliery only is there a thin bed of sandstone between this coaly material and the Gubbin and Balls.

At a distance below the Gubbin and Balls, which varies from 18 to 50 feet, there occurs a coal 2 to 4 feet in thickness, which is called sometimes the Singing* coal and sometimes the "Mealy-grey"† coal.

In the Wolverhampton district the thickness of the beds between the Gubbin and Balls and the Singing or Mealy-greys coal seems never to exceed 24 feet, nor fall below 18 feet, except where a bed of green rock or trap interposes. At Trentham new colliery, north of Willenhall, however, these beds are 35 feet, and towards Bentley, at "the Island," half a mile east of Willenhall, it is 50 feet, as also at the Monmore colliery. Farther north-east, however, about Birch Hills and Bloxwich, the thickness again diminishes to 33 feet or 26 feet, and the Singing coal itself is only 10 inches or 1 foot in thickness. At Haddocks Moor, the most northern locality where this coal has been pierced, it was found to be 1 foot 4 inches in thickness, and to lie at a depth of 48 feet 6 inches below the Deep coal, or 37 feet below the Gubbin ironstone. They passed also through another little 6-inch coal at a depth of 34 feet below the Mealy-grey coal.

In the part of the field south of Bilston there is but little mention of this coal, but it appears in a section at Tipton-green,‡ where, at a depth

---

* This name was described to me as arising from the fact, that as they passed through it in some places, the gas could be distinctly heard issuing from its crevices "like the singing of a tea-kettle."

† Where it has this designation, it is said to be of a greyish hue and to be partly friable or "mealy."

‡ Given me by Mr. Johnson of Dudley.

below the Bottom coal of 37 feet (excluding trap) there is "Singing coal 4 feet." If from this we take off a portion to include the Gubbin and Balls, &c., the remaining thickness will be very nearly equal to what these beds have near Wolverhampton.

In some parts between Wolverhampton and Bilston I believe the Singing or Mealy-greys coal is now "gotten" (1852), and is looked on by the iron-masters as a valuable help to their resources.

The materials composing the beds just described are generally an alternation of fire-clay, clunch, or binds, with rock or rock binds, sometimes the argillaceous, sometimes the arenaceous character predominating. In the neighbourhood of Bentley one or two little coals a few inches thick likewise show themselves.

37. *Measures between the Mealy-grey coal and the Blue-flats ironstone.*—Below the Singing or Mealy-grey coal we get a mass of beds consisting sometimes entirely of fire-clay, more frequently of alternations of fire-clay and rock, varying in thickness from 16 feet to 50 feet, before we reach the Blue-flats ironstone. As in the case of the beds above described, these measures are also thickest in the Bentley district, where they contain also one or two little beds of coal, and in their lowest portion some ironstone balls. The alteration in thickness in these beds is sometimes rapid, as in a colliery at Portobello near Wolverhampton, in two pits within 150 yards of each other, the beds consisting in both of fire-clay and rock, varied from 16 feet to 29 feet in thickness. Elsewhere about Wolverhampton they have a pretty constant thickness between 20 and 25 feet.

The two groups of beds, namely, those above and those below the Singing or Mealy-grey coal, while they each vary in thickness in different places, usually vary in such a way as to balance each other and maintain a certain mean aggregate thickness.

The aggregate thickness of the whole beds between the Gubbin and Balls, and the Blue-flats ironstones is, near Wolverhampton, never more than 53 feet nor less than 40 feet (exclusive of trap); but north and east of Willenhall, around Bentley, and up to Bloxwich, it is never less than 70 feet, and sometimes reaches 85.*

It will be important to bear these facts in mind when we come to describe the trap rocks which have been intruded into these beds.

38. to 42. (*I.* 14, 15, 16.) *The Blue-flats ironstone, together with the Diamonds and Silver threads ironstones.*—We have now to describe the lowest recognizable measures in the whole of the South Staffordshire coal-field, those beneath which neither coal nor ironstone have ever been found that were of the least value.

The Blue-flats ironstone is confined absolutely as a workable measure to the district between Wolverhampton and Walsall, scarcely going south of Bilston, nor so far north as Bloxwich. It is an easily recognizable ironstone, as it occurs usually in regular bands a few inches thick, which are smoothly jointed, and are but slightly concretionary in structure. When brought to the pit bank the lumps of ironstone look like large rather irregular bricks; they are pale brown at first, but from

* In Samuel Arblaster's pit near the Brown Hills before mentioned, they got some ironstone somewhat resembling the Blue flats at a depth of only 12 feet (white tender rock) below the supposed Gubbin and balls. The identification of the measures, however, is too doubtful for us to found any argument on.

exposure to the air assume a dull blue or purplish look. This colour, joined to the flat pavement-like form in which they are found below, gives them their name.

The ironstone usually occurs near Wolverhampton in two, three, or four regular bands, interstratified with clunch or clod, as in the following sections:—

*The Cockshutts.**

	FT.	IN.	FT.	IN.
Clod	4	0	–	
Ironstone	–		0	4
Clod	2	0	–	
Ironstone	–		0	2
Clod	3	0	–	
Ironstone	–		0	3
	9	0	0	9

Park Hall.†

	FT.	IN.	FT.	IN.
Top stone	–		0	6
Binds, &c.	2	0	–	
Second stone	–		0	3
Parting	1	3	–	
Third stone	–		0	4
Ground with chitterstone	4	2	–	
Bottomstone	–		0	3
	7	5	1	4

Chillington.‡

	FT.	IN.	FT.	IN.
Stone	–		0	5
Clod	1	0	–	
Stone	–		0	5
Clod	0	6	–	
Stone	–		0	2
	1	6	1	0

The Blue flats are mentioned with a thickness of about 3 feet a Deepfields and Bradley, and as 5 feet thick at Darlaston; but what proportion of ironstone they contain there I do not know.

In some places near Wolverhampton mention is made of the "Bristol diamonds ironstone," just below the Blue flats. It seems there to be very poor and trifling; but as we proceed to the north-east we find around Bentley and Walsall the Diamonds ironstone as rich and important as the Blue flats, and, moreover, the "Silver threads" coming in between them, with much ironstone in bands and cakes, in the intervening

* Mr. Griffiths. † Lord Ward's office.
‡ Murchison's Silurian System.

measures. The section here is of a totally different character from that near Wolverhampton, as may be seen by the following examples :—

*Bentley Estate.**

		FT.	IN.	FT.	IN.
Blue flats	Ironstone			0	4
	Binds	3	0		
	Ironstone			0	1
	Binds	1	6		
	Ironstone			0	2
	Binds with ironstone nodules	9	8		
Silver threads	Ironstone			0	1
	Binds	1	0		
	Binds with ironstone	3	4		
	Ironstone			0	2
	Binds	6	0		
Diamonds	Ironstone			0	3
	Binds	1	4		
	Ironstone			0	2
	Binds	1	5		
		27	3	1	3

(*See Vertical Sections, sheets* 16 *and* 26, *Nos.* 6, 40, *and* 45.)

Ryecroft, north of Walsall.†

		FT.	IN.	FT.	IN.
Blue flats	Ironstone cake			0	3
	Blue clod	1	0		
	Ironstone			0	3
	Blue and white clod	3	7		
	Ironstone balls, called grandads			0	8
	White clod	10	0		
Silver threads	Ironstone			0	3
	White clod	2	8		
	Ironstone			0	4
	White clod	3	0		
	Ironstone			0	3
	White clod	7	6		
	Balls of ironstone (sometimes)			0	8
	White clod	7	0		
Diamonds	Ironstone			0	3
	Black clod	2	0		
	Ironstone			0	4
		36	9	3	3

(*See Vertical Sections, sheet* 16, *No.* 7.)

Going still farther north, again, the ironstones seem to be rapidly dying out and disappearing. At Dudley Brothers colliery, for instance, about half a mile west of Bloxwich, although these measure were still recognizable, they contained so little ironstone as not to be worth working ; while around Pelsall they sank at one place 150 feet below the Bottom coal without finding either coal or ironstone, till at that

* Mr. George. † Mr. Arthur Sparrow.

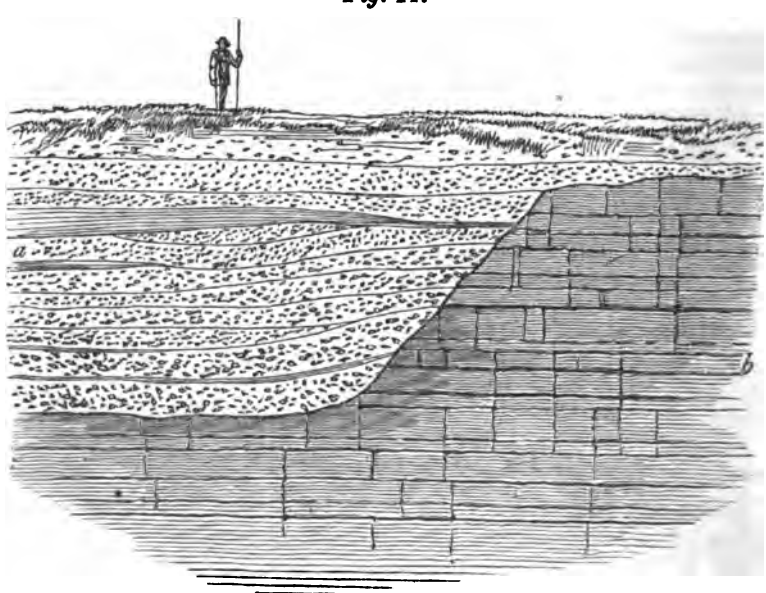
depth they came on a little "lean" ironstone, which was conjectured to represent the Blue flats.

43. *The base of the Coal-measures.*—It remains now only to investigate the nature and thickness of the beds that lie below the Blue flats and other ironstones, or, where those measures are not present, the lowest beds of the Coal-measures in each locality.

I may premise, that in the cutting of the railway near Trindle Gate, just east of Dudley, the base of the Coal-measures was very well exposed, resting on the Silurian shale, and exhibiting the following facts.

The Coal-measures here consisted of pale yellowish sandstones, many of them argillaceous (rock binds), with some small beds of shale or clay. The Silurian shale was a compact blue shale in thick beds, lying very regularly in a nearly horizontal position. At one part of the section some of the upper beds of the Silurian shale ended in a moderately sloped cliff, against which the sandstone of the Coal-measures abutted, while they reposed on the lower beds of shale that continued beneath them. As both groups of beds were nearly horizontal, no unconformity could be perceived between them, except just at the little Silurian cliff. Here the lamination of the sandstones became oblique, trying to conform to the slope of the cliff, and the lower beds of it, both near the cliff and for some yards back, contained pebbles and many small angular fragments. The pebbles were mostly white crystalline quartz, with some rolled pieces of ironstone. The angular fragments were chiefly Silurian shale and limestone. The cliff was about 20 feet high (see Fig. 11.)

Fig. 11.



a Coal-measures. *b* Silurian shale.

From this very instructive instance we learn generally how, with perfect apparent local conformability, there may be still on the large

scale a very great amount of unconformability between two formations, and in this special case we see the nature of the relation between the Coal-measures and the Silurian rocks of the South Staffordshire coal-field; that the Silurian rocks were greatly denuded and worn away, and cliffs and hollows formed in them, on, against, and over which the Coal-measures were deposited, both lying in a nearly horizontal position.

In the district south and west of Dudley there has been no pit sunk from any of the known beds of the Coal-measures down to the Silurian, unless they reached that formation in the Blackheath colliery, south of Rowley Regis (see Vertical section, sheet 18, No. 26). In that abortive search for valuable coal or ironstone, they reached, at 570 feet from the surface, the representative of the Thick coal in a debased and worthless form, and they sank to a depth of 121 feet below it, meeting with only a few trifling beds of coal or ironstone. At a depth of 661 feet from the surface, and 81 feet below the Thick coal, they met what is described as "red parting and limestone, 1 inch," and below that they found thick and regular beds of "rock binds," separated by inch partings of white clay. Now if the sinkers had never before worked in the Silurian rocks they might easily have described those as "rock binds," and they bored through *precisely similar materials* for 300 feet below the bottom of the shaft. This statement makes it very probable that the last 340 feet out of the 1,001 feet passed through altogether, consisted of Silurian shale, since it is totally contrary to the nature of the South Staffordshire Coal-measures to maintain one lithological character through so great a thickness. If these rock binds were Silurian shale, then there was only 81 feet of Coal-measures between it and the Thick coal in that locality.

The nearest deep sinking to this that I am aware of is the one at the Level colliery north-east of Brierley Hill, made by Mr. Benjamin Gibbons, and quoted by Sir R. I. Murchison in his Silurian System, p. 478. Of this pit we have already investigated the details, and endeavoured to identify the lower coals. The following abstract will give us all further necessary information about it:—

	FT.
To the bottom of the Thick coal - - -	240
To ditto of 2nd Heathen ditto - -	18
To ditto of Stinking ditto - - -	34
To ditto of New mine (?) ditto - -	37
To ditto of Fire-clay (?) ditto - -	15
To ditto of Bottom ditto - - -	29
To ditto of (small coal and batt 8 in.) -	19
Alternations of "rock," fire-clay, clunch, and binds, varying from 2 feet to 10 feet each - -	109
Dark gritty rock, with conglomerate - -	26
Light blue clunch - - - - - -	3
Below which they bored in *red clunch* - -	60
	590

Making a total of 217 feet below the Bottom coal, or 350 feet below the Thick coal, without meeting with anything that appears like Silurian rocks.

At the Leys ironworks, north-west of Brierley Hill, Mr. Firmstone sank a pit, as follows:—

	FT.
To the bottom of the Thick coal - - -	492
To ditto of Heathen ditto - - -	9
To ditto of Stinking ditto - - -	10
To ditto of New mine (?) - - -	24
Beds of fire-clay, rock, binds, redand grey clod, and *red rock*, 1 foot to 7 feet each - - -	39
Red sandstone grit full of pebbles - - -	38
	612

Making a total of 120 feet below the Thick coal; having reached which depth the water burst in on them with such force and rapidity as to oblige them to abandon the sinking.

It is singular that in each of these pits, although at different depths, the lowest beds were red, clunch in one case, (which might be marl,) and sandstone in the other. One might speculate on some beds belonging to the Old red sandstone having come in, were it not that many of the true Coal-measures, both above and below the Thick coal, contain much red and mottled marl and clunch.

At Corbyns Hall Mr. Gibbons sank 172 feet below the Thick coal, the bottom beds being alternations of clunch and rock binds, when a quantity of *salt water* rushed in with such force as nearly to drown the mines.

At Shut End mines Mr. Foster sank 111 feet below the Thick coal, passing 16 feet below the representative of the Fire-clay coal, and found much of the water in the lower measures very salt.

The following is a complete abstract of the Graveyard Trial pits, south of Lower Gornal:—

	FT.
To bottom of Thick coal - - - -	43
„ „ Heathen do. - - - -	15
„ „ Sulphur do. - - - -	43
„ „ New mine do. - - - -	24
„ „ Fire-clay - - - -	8
„ „ Bottom - - - -	40
To bottom of another little coal passing through many beds of rock, &c. - - - -	112
Several beds of rock - - - -	21
	306

(*See Vertical Sections, sheet* 18, *No.* 23, *lower part.*)

Making a total of 133 below the Bottom coal, or 263 feet below the Thick coal, without attaining the base of the true Coal-measures.

For ascertaining the exact thickness of Coal-measures between any known bed and the top of the Silurian formation in any part of the field, we have but scanty data in the pit sections. Even where it is certain, or highly probable, that the sinking was continued down into the Silurian rocks, we are often left to guess at the place of the exact boundary between the two formations, since the miners are but little

apt to observe any distinction between the grey shales of the coal-measures and the shales of the Silurian series. Where the latter also are at all hard, or slightly arenaceous, the miners are likely to call them "rock binds," and we are thus liable to class them as Coal-measures. Mention, too, is sometimes made in the sections of a "blue rock;" now, whenever I have seen any beds thus described, I have always found them a compact slightly arenaceous clay rock, so greatly indurated as to form a hard tough stone: and, in sinking a shaft, the Silurian shale of this neighbourhood would be likely often to have these characters, and thus be called by the miners "blue rock." Whenever there is a white or strong brown rock mentioned, I should always consider it as part of the Coal-measures, because I have never seen or heard of any sandstones of that colour in the Silurian shales of this district; and if it were limestone rock, they would almost certainly have described it as such.

With these remarks I now lay before the reader the following ten extracts from pit sections, beginning at the most southerly, and proceeding to the north and east:—

1. *Shaver's End, just north of Dudley.*

	FT.	IN.	
Bottom coal	9	2	
Rock and clunch	39	0	68 ft.
Ironstone measure may = Blue flats	7	0	68 ft.
Fire-clay, rock, and pebbly rock	22	0	68 ft.
Blue clunch	4	0	
Bavin and limestone	72	0	
	153	2	

(*Vert. Sects., sheet* 18, *No.* 36.)

2. *Dudley Port, Bagnall's Limestone Pit.*

	FT.	IN.
Bottom (?) coal	1	6
Fire-clay, black ground, rock binds, and rock	60	0
Bavin (Silurian shale)	69	0
Limestone	27	0
Limestone	24	0
	181	6

(*Vert. Sects., sheet* 16, *No.* 13.)

3. *Tipton Green.*

	FT.	IN.	
Bottom coal	11	9	
Fire-clay, rock, &c.	37	0	71 ft.
Singing coal	4	0	71 ft.
White rock and pebbles	30	0	71 ft.
Blue binds	130	0	
	212	9	

(*Vert. Sects., sheet* 16, *No.* 12.)

4. *Foxyards.*

	FT.	IN.	
Bottom coal	9	0	
Fire-clay, black ground, and rock	80	0	92 ft.
Ironstone (Blue flats?)	4	6	92 ft.
Strong pebbly light coloured rock	7	6	92 ft.
Strong blue rock	36	0	
	137	0	

5. *Tipton-moat.*

	FT.	IN.
Bottom coal - -	9	6
Fire-clay, black ground, binds, and ironstone, batt and coal, white rock, &c. - - -	71	0
Blue rock and binds	112	6
Binds - -	17	0
Stone and binds -	172	0
	382	0

6. *Deepfields.*

	FT.	IN.	
Bottom coal	12	0	
Rock, clunch, and rock binds -	69	0	71ft. 6in.
Blue flats -	2	6	
Blue rocky clunch	150	0	
Limestone -	50	0	
	263	6	

7. *Parkfield, near Wolverhampton.*

	FT.	IN.	
Bottom coal -	11	2	
Various coal-measures -	68	0	133ft. 6in.
Blue flats -	10	9	
Diamond clod	2	3	
Strong white rock -	22	6	
Dark slaty ground -	30	0	
Limestone bavin			
	144	8	

(*Vert. Sects., sheet* 17, *No.* 20.)

8. *Chillington Colliery, near Wolverhampton.*

	FT.	IN.	
Bottom coal -	12	1	
Various coal-measures -	89	0	91ft. 6in.
Blue flats -	2	6	
Measures undescribed	240	0	
Limestone clunch, with small bands of limestone	210	0	
	553	7	

(*Vert. Sects., sheet* 16, *No.* 9.)

9. *Bentley Limestone Pit.*

	FT.	IN.	
Bottom coal -	8	8	
Various coal-measures -	89	0	146 ft.
Blue flats, Silver threads, and Diamonds	28	0	
Binds, fire-clay, and rock	29	0	
Binds and parting, Silurian	117	0	
Binds with thin limestones -	97	0	
Little limestone	12	0	
Shales with limestone -	118	0	
Thick limestone	33	9	
Shales with limestone -	18	0	
	550	5	

(*Vert. Sects., sheet* 16, *No.* 6.)

10. *Ryecroft.*

	FT.	IN.
Blue flats, Silver threads, and Diamonds - -	41	6
Rough rock - - -	6	0
Limestone, clunch, binds, and partings - -	183	0
Little limestone - -	12	0
Limestone clunch, with hard limestone balls -	120	0
Thick limestone - -	36	0
	398	6

(*Vert. Sects., sheet* 16, *No.* 7.)

In the first six of these sections there is a remarkable agreement in the total thickness of Coal-measures below the Bottom coal, supposing that in each case the "blue binds" or "blue rock," from its colour and its preserving a uniformity of structure through so much greater thickness than the Coal-measures usually do, be the Silurian shale. At Parkfield (No. 7), the beds below the Bottom coal are thicker than elsewhere, in consequence of the extra thickness in those between the Blue flats and the Silurian shale. At Chillington (No. 8), we have no means of ascertaining this point, or of saying anything more than that they were in the Silurian shale when they got down 240 feet below the Blue flats.

At Bentley, the Coal-measure beds below the Bottom coal have thickened to 146 feet, with 30 feet below the Blue flats group, while at Ryecroft there is only 6 feet of Coal-measures between that group and the top of the Silurian shale.

In all cases, the lowest beds of Coal-measures, where ascertainable, were found to be sandstone, generally containing pebbles.

Thickening in the lower beds of the Coal-measures as they range from south to north.—In page 20 is given a table of the beds, with the minimum and maximum thickness of each, as described in the foregoing pages. If, looking at those below the Thick coal, the minima were added together, we should only have a thickness of 98 feet for the whole of the beds between the bottom of the Thick coal and the top of the Blue flats. If the maxima were added, on the contrary, we should have a total thickness of 539 feet. The mean of these two numbers is 318. Now it is a remarkable instance of the way in which the frequent variations in the thickness and character of the beds are equalized among themselves, and a certain mean thickness kept, that the mean of 13 pit sections, distributed pretty equally over various parts of the district, gives 322 feet as the actual mean thickness of the beds between the base of the Thick coal and the top of the Blue flats. If, moreover, we arrange these 13 sections in the order of their thicknesses, we shall find that that will very nearly be the order of their latitude, the thinnest section being the most southerly and the thickest the most northerly; the others being nearly regularly arranged between them. I add at the beginning a section still further south, at Foxyards, where it was doubtful whether the ironstone were the Blue flats or not; the probability of its being so having become much greater from the way in which it harmonizes with the other sections.

	Thickness between the Thick Coal and Blue Flats in Feet.
1. Foxyards - - -	240
2. Bradley - - - -	270
3. Deepfields - - -	274
4. Crabtree piece, near Bilston -	290
5. Stowheath - - -	300
6. Friezland - - -	302
7. Stowheath - - -	306
8. Chillington Colliery - -	312
9. Rough Hills - - -	329
10. Priestfield - - -	333
11. Ettingshall Lodge - -	336
12. Bentley Estate - - -	365
13. Bentley, another shaft - -	378
14. Bloxwich - - -	395

This exhibits very clearly what has been before alluded to in describing these beds, the gradual thickening of them towards the north, the total section being 150 feet greater at one end than the other.

If we were to take the thickness of the beds from the base of the Thick coal to the base of the Bottom coal, we should get precisely similar results as a whole. As, however, we possess 30 sections, which include the necessary data for the Bottom coal, while we have only 13 for the Blue flats, we should expect to find one or two of them a little out of their place, owing to partial and strictly local thickening or thinning of a few beds simultaneously, while generally these variations in thickness balanced each other. I add this list arranged in order of thickness :—

		FEET.	
*1.	The Graveyards	120	The south-western district.
2.	The Level	133	
3.	Upper Gornal	133	
4.	Foxyards	159	Between Dudley and Wednesbury.
5.	Tipton Green	160	
6.	Coneygree	167	
7.	Tipton Moat	167	
8.	Bradley Lodge	176	All between the latitudes of Coseley and Bilston.
9.	Ettingshall, near Cann-lane	176	
10.	Highfields	194	
11.	Highfields	196	
12.	Highfields	203	
13.	Deepfields	205	
14.	Bradley	213	
15.	Dockmeadow	216	
16.	Priestfield Furnace	225	All on or about the latitude of Bilston.
17.	Bilston Meadow	228	
18.	Priestfield Colliery	229	
19.	Friezland	232	
20.	Crabtree Piece	240	
21.	The Wallbutts	242	
22.	Chillington Colliery	250	All north of Bilston, near Wolverhampton.
23.	Stowheath	253	
24.	Rough Hills	256	
25.	Bentley Heath	263	Still farther north.
26.	Bentley Hall	265	
†27.	Lower Bradley	266	South of Bilston.
‡28.	Ettingshall Lodge	270	Due west of Bilston.
29.	Bentley, northern part	276	North of 26.
30.	Bloxwich	291	North of 29.

It follows, from an inspection of this list, that our identification of the Bottom coal in the three sections in the district south and west of Dudley, namely, Nos. 1, 2, and 3, that identification being founded only on the details of the sections, is rendered still more probable, from its harmonizing so well with our general results. It agrees, also, well with the statements before given as to the splitting up and separation of the Thick coal towards the north, and the coming in of other beds in that direction not known towards the south, and shows that the

* In geographical order the Graveyards would come between Nos. 2 and 3.

† The abnormal position of this section is due to a local thickening of the beds between the Thick and Heathen coals.

‡ Due to a local increase in the thickness of several of the measures, which is compensated for in the beds below the Bottom coal, as in the Blue flats list this section takes its proper geographical position.

thickening in those upper measures is only a still further carrying out of a structure or character common to the whole coal-field.

Connexion of the Wyrley and Essington district with the rest of the Coal-field.—We have now given a detailed description of the beds constituting the Coal-measures of the central and southern portion of the field, and have traced the lower beds in detail as far north as the Brown Hills.

The Heathen and Sulphur coals were also traced in detail up to the neighbourhood of Bloxwich, and have been mentioned as forming the uppermost measure in some of the more western pits in the Brown Hills district.

The dip of the beds from Bentley to Bloxwich, and from Bloxwich all over the Pelsall and Brown Hills district is from east to west, at a low but steady angle of inclination. The dip of the beds at Essington and Wyrley is likewise from east to west at the same gentle angle. It follows that unless there be a great fault or a great flexure running north and south between Pelsall and Essington on the one side, and the Brown Hills and Wyrley on the other, that the beds which are worked along the eastern side of this portion of the field dip under those that are worked on the western side, and would be found underneath them if a sufficiently deep sinking were made.

Two such explorations have been made, as will be seen presently, one a boring and the other a shaft, and though not quite conclusive in their results, are yet in favour of that belief as far as they go.

Neither from Bentley nor from Pelsall have there been any continuous workings up to Essington and Wyrley, a width of a mile and a half or two miles of unexplored ground isolating the Essington and Wyrley collieries from the rest of the coal-field. It is believed, from some sinkings that were made formerly near the New Invention, and from other appearances, that this belt of unexplored ground is greatly cut up by sheets and masses of trap rock. We are accordingly left to the following evidence in order to connect the Essington and Wyrley beds with the other beds of the coal-field, and prove the statement made in the General Description (Chapter V.), that the coals there represent the Thick coals.

We have seen that the Bottom coal and the beds immediately above it are worked continuously from the neighbourhood of Bilston and Wolverhampton under the Bentley and Bloxwich districts, up to Pelsall and the Brown Hills; and that as they range from the former towards the latter, the measures increase in thickness, and beds which lie together in the southern part are, as they run north, split up by intervening measures and sometimes widely separated from each other. It will be remembered also that between Bilston and Wolverhampton the Thick coal has already lost the two upper beds, which have gone off as the Flying reed, and cropped out south of the Lanesfield fault, and that the remaining part is also separated into two masses by an intervening bed of shale 10 feet thick, called "Hob and Jack."

The measures rise from this district gently towards the north, the Thick coal cropping out directly, and the beds below it gradually and successively until at Bentley Hall and Deepmore Coppice the Bottom coal is but a little way below the surface of the ground.

A little north of Deepmore coppice a great fault running nearly east and west throws down the measures to the north to the extent of 360 feet so that the Bottom coal is then about 400 feet deep, with all the measures above it easily recognizable up to the Heathen coal, which is there about 144 feet deep. Now, as the Heathen coal about Bilston is never more than some 30 feet below the Thick coal, it follows that we

ought to have, north of the Bentley fault, the Thick coal itself some 80 or 90 feet at least below the surface. What is really found there is the following :—

		FT.	IN.	FT.	IN.
1.	Soil, gravel and clay	-	-	21	11
2.	Coal (called Old man's coal)	-	-	9	7
3.	Fire-clay, clunch, rock, and binds	54	0		
4.	Little coal	1	10	56	6
5.	Fire-clay	0	8		
6.	Coal (called Bentley Hey coal)	-	-	5	0
7.	Fire-clay, rock, and binds	10	1		
8.	Ironstone (called the Binds)	1	7		
9.	Coal (called the Binds coal)	1	2		
10.	Clunch and binds	6	6		
11.	Gubbin ironstone	1	9		
12.	Gubbin coal and batt	1	2	47	9
13.	Fire-clay	0	10		
14.	Coal	0	7		
15.	Binds	21	0		
16.	Clunch and ironstone (Lambstone)	3	0		
17.	Black batt	0	11		
18.	Coal (Heathen coal)	-	-	1	8
				143	3

Of this set of beds, No. 11 is the same as the Little Gubbin, already described, farther south. It has, however, here two small coals below it, and the thickness between it and the Heathen coal is 4 or 5 feet greater than the thickness about Bilston.* There is above the Little Gubbin, moreover, another small coal and ironstone (here called the Binds coal and ironstone), of which we have little or no trace to the southward ;† and we must look upwards of 19 feet above the Little Gubbin (instead of only 5 or 6, as near Bilston,) before we meet with any considerable bed of coal. We then get two beds of coal, (Nos. 4, 5, and 6,) 7½ feet thick together, including 8 inches of fire-clay between them, over which are 54 feet of alternations of fire-clay, clunch, binds, and rock, and then another bed of coal 9 or 10 feet in thickness. It is clear, nevertheless, from their position above the Heathen coal, that these latter coals, namely, No. 6, the "Bentley Hey," and No. 2, the "Old man's" coal, notwithstanding their being 54 feet apart, must be the representatives of the lower beds of the Thick coal.

Now, the Bentley Hey coal, and the Heathen coal below it, are found at intervals, and worked, north of Bentley, up to the New Invention and Bloxwich. They have never been worked quite continuously, as they are said to be frequently thrown in and out of the ground, not only by a succession of small faults and one large one, but also by several undulations of the beds.

The Bentley Hey four-foot coal has also been worked north of the New Invention, with a general dip to the west or W.N.W., that is in the direction of Essington.

In the cutting of the canal, just south of Sneyd Reservoir, the crop of a coal was seen which Mr. George, of Bentley, now informs me he

* It will be recollected that some distance south of Bilston, around Dudley for instance, the beds between the Little Gubbin and the Heathen coal thin out to nothing, and the ironstone measures rest directly on the coal.

† There are sometimes small beds of ironstone both above and below the Little Gubbin in the southern part of the field, as at Claycroft, near Dudley, see p. 54.

believe to be this same Bentley Hey coal, and that its crop runs off towards Moseley Field; the dip being very gentle towards Essington. Now supposing that it dips at an angle of 3° from the canal, just by Sneyd Pool, to Mr. R. Mills's Essington colliery, and that the ground was quite level, which it is nearly, and allowing the distance in a straight line to be $1\frac{4}{10}$ mile, or nearly 7,400 feet, the depth of this coal would be 392 feet from the surface at the Essington colliery. It would, however, have to cross the Old Mitre fault, which is a downthrow to the west of 65 yards (or 195 feet) thereabouts, so that the total depth of the coal would be (392 + 195 = 587 say) about 600 feet. Moreover, this Bentley Hey four foot-coal has in the Great Bentley trough another coal, called the Old Man's coal, 8 or 9 foot thick, at the height of 54 feet above it.

Now at the Essington colliery a Four-foot coal was found at a depth of 593 feet, and 38 feet above it was found a compound seam of coal, 8 feet 7 inches thick.

The probability is considerable that these are the very same coals which are known at Bentley as the Old man's 9 foot coal, and the Bentley Hey or Top four-foot coal.

Now, over this coal at Essington come all the Wyrley coals, presently to be described, and known as the Broach, Cannel, Charles, Yard, and Robins, all in their proper places, which proves this coal to be that which at Wyrley is called the Bottom coal or Eight-foot coal.

This coal which at Wyrley is called the Eight-foot or Bottom coal (because it is the lowest coal that has ever been worked in that district) is known all over the Essington and Wyrley district, and it is known to crop out finally* about Jacob's Hall, and along a north and south line running parallel to and a little east of the turnpike road between Bloxwich and Clunch Bridge.

The late Mr. Gilpin had a boring made below the so-called Bottom coal, of which his agent, the late Philip Baker, of Landywood, gave me the following account :—

	FT.	IN.
Coal (called Bottom coal) - -	7	0
Clunch with occasional ironstone -	40	7
Coal - - - - -	3	0
Fire-clay with alternations of clunch and rock - - -	113	6
Coal - - - - -	2	3
Clunch with small ironstones and some beds of rock - -	68	8
Coal - - - - -	1	5
Clunch with little ironstones and some rock - - -	38	3
Coal - - - - -	2	0
Fire-clay, rock, and clunch - -	30	2
Coal - - - - -	0	4
Fire-clay and clunch - -	10	2
Coal - - - - -	1	6
Fire-clay and clunch - -	4	2
	323	2

* I say finally, because the whole district is broken up by a multitude of faults, so that all the coals crop and are thrown in again several times. The lines, therefore, drawn on the map about Wyrley and Essington must be taken rather as marking the general limits than the actual outcrop of the coals, while it has hitherto been found impracticable to delineate the numerous faults on the small scale of the Ordnance map.

The present Mr. Gilpin sank a shaft, at a place called Highfields, a little south of Church Bridge, to the depth of 211 feet (70 yards) below the so-called Bottom coal, of which the following is an abstract of the particulars as he communicated them :—

	FT.	IN.
Coal (called Bottom coal) - -	8	0
Fire-clay, black batt, and brown ironstone - - -	4	1
Coal - - - - -	0	6
Binds, clod, &c. with ironstone -	32	5
Coal - - - - -	3	0
Fire-clay, binds, &c. - -	26	0
Coal - - - - -	1	0
Fire-clay, clunch, binds, &c. -	132	6
Coal (stinking) - - -	1	2
Fire-clay - - - -	2	0
	210	8

The boring I esteem valuable solely as proving there was that much depth of Coal-measures below the Bottom coal, for I have long come to the conclusion that all indications of thickness of particular beds, &c. derived from borings are too uncertain to be depended on.

The existence of a Three-foot coal, however, about 37 or 40 feet below the Wyrley bottom or Eight-foot is proved from both the boring and the sinking. This is without doubt the Bentley Hey coal. The sinking places a foot coal at 26 feet below this Three-foot, and if the latter be the Bentley Hey coal the foot coal may possibly be the Heathen. At a depth of 132 feet 6 inches underneath this there is, according to the sinking, a coal called Stinking, 14 inches thick. This may very well be the true Stinking or Sulphur coal, which in the southern part of the field lies at a mean depth of 70 feet below the Heathen, though it is not more than 50 or 60 feet below it at Bentley and the Birch Hills.

I believe that Mr. Gilpin himself was convinced that the Stinking coal which he reached was the Top or Two-foot coal of the Brown Hills, which is almost certainly the true Sulphur coal, basing his opinion not only on the sulphureous quality of the coal, but on the occurrence of some ironstone measures above it, believed to be the Pennystone measures, and another which was recognized or supposed to be recognized as the New mine ironstone clod, although it was devoid of ironstone. If this be the Stinking coal, it follows that the Brown Hill and Pelsall coals may be found below it. In this opinion I entirely concur, though it is impossible to feel sure that the lower beds will retain the same thickness and value in the deep or western side of the field which they have on the eastern side.

If there should still rest any doubt upon anybody's mind as to the Wyrley and Essington coals being the representative of the Thick coal in an expanded form, perhaps the following argument may be conclusive. If these coals be other than the Thick coal they must be either above it or below it. If they are entirely above it then the Thick coal must lie in the district between Essington and Wyrley on the one side and Pelsall and the Brown Hills on the other, and must crop out to the surface in that district, inasmuch as beds, which are *certainly below* the Thick coal, themselves crop out to the eastward of it. It is not very likely, indeed we may say it is quite impossible, that such an outcrop of Thick coal could exist without having been long ago dis-

covered, ranging, as it must do, for a distance of several miles between Bloxwich and Norton.

If, on the other hand, it be supposed that the Wyrley and Essington coals belong to the beds below the Thick coal, then we have at the Essington colliery a thickness of nearly 600 feet of coal-measures full of good workable coals, to which we must add 280 feet for the depth of Mr. Gilpin's boring below the Three-foot coal which lies 40 feet below the so-called Bottom coal. We should then have a thickness of nearly 900 feet of coal measures below the Thick coal containing many thick and excellent coals, but totally different from the beds which are elsewhere to be found below the Thick coal, while in no other part of the coal-field is there a greater thickness below it than 400 or 500 feet at the very outside, the greatest known thickness being 340 feet.

This supposition then would involve still greater changes than are supposed on the other side, besides being opposed to all other species of evidence.

Details of Wyrley and Essington.—It would hardly be worth while to analyse the pit sections of Essington and Wyrley with the minuteness of detail which has been given to those of the central and southern portion of the field, even if we possessed the requisite materials. But as the coals themselves are the only beds of much value, there is little or no mention made of the nature of the substances that lie between them in most of the sections that have been supplied to us.

The ironstone that is considered of most value is one below the Yard coal of Wyrley, which is therefore called the Yard coal ironstone. Mr. Gilpin of Wedges Mills informs me that this resembles the black band of North Staffordshire, but that it varies a good deal in character. In one shaft the measure was 4 feet thick, the top stone being 4 inches, the middle 8 to 12 inches, and the bottom 3 to 5 inches; while in the next shaft there were two layers of top stone, one being very good, with occasional large balls of ½ to ¾ cwt. each. In another adjacent shaft there was in the place of the top stone "merely a white chalky stone, without any iron in it, or a trace of it." There is also another regular measure of ironstone a few feet below this, but it has never been found sufficiently good to work; and with the occasional exceptions mentioned above, and the ironstone immediately above the Bottom or Deep coal, all the ironstones found about Wyrley are very poor in quality.

Mr. Gilpin has lately communicated to me the following section of a pit in the Wyrley field which may be taken as a correct average account of the measures.

			FT.	IN.	FT.	IN.
1.	Above Robins coal		20	0	20	0
2.	Robins Coal				8	0
3.	Fire-clay and batts		14	0	18	0
4.	Ironstone measure		4	0		
5.	Yard Coal	Coal	3	0	5	3
		Fire-clay	1	6		
		Coal	0	9		
6.	Fire-clay		3	0	45	0
7.	Black batts, with two small bands of ironstone and nodules of ditto		4	6		
8.	White clunch		10	6		
9.	Black batts and dark ironstone, very thin in the ground		3	9		
10.	Peldon		1	6		
11.	Dark batts		3	9		
12.	Fire-clay, rock and binds		18	0		

		FT.	IN.	FT.	IN.
13.	Charles Coal	-	-	3	0
14.	Fire-clay	7	6		
15.	Rock binds	5	0		
16.	Black batts	0	6		
17.	Rough white fire-clay	5	0		
18.	Black clod	1	6		
19.	White clunch	6	0		
20.	Ironstone	0	2		
21.	White clunch	2	10	62	6
22.	Coal	1	0		
23.	Brown fire-clay	6	0		
24.	Black clod	1	0		
25.	Fire-clay	5	0		
26.	Dark clunch	6	0		
27.	Binds and rock	3	0		
28.	Clod	12	0		
29.	Cannel Coal	-	-	4	0
30.	Fire-clay	4	6		
31.	Dark clunch	7	6		
32.	White clunch	19	6		
33.	Srong fire-clay	4	0		
34.	White clunch	4	0	74	0
35.	Soft white fire-clay	3	0		
36.	Strong white clunch	12	0		
37.	Strong white rock	10	6		
38.	Strong white clunch	9	0		
39.	Brooch Coal	-	-	3	9
40.	Clod	1	6	1	6
41.	Benches Coal	-	-	2	3
42.	Fire-clay	3	0		
43.	Rock and binds	39	0		
44.	Measures containing two bands of ironstone 4 inches each, and chance balls of ironstone called the Wyrley Bottom coal stone	4	0	48	0
45.	Strong clod	2	0		
46.	Wyrley Bottom or Deep Coal	-	-	8	0
				302	9

If to this we add the sinking at Highfields, of which the abstract was given at p. 90, we shall have an accurate idea of the measures passed through in the Wyrley district.

		FT.	IN.	FT.	IN.
47.	Dark fire-clay	1	6		
48.	Grey fire-clay	2	0		
49.	Black batt	0	4		
50.	Brown ironstone	0	3		
51.	Coal	0	6		
52.	Strong binds	4	0		
53.	Ironstone	0	2		
54.	Dark clod	1	3		
55.	Brown ironstone	0	3		
56.	Dark clod	1	3		
57.	Grey clunch	1	8		
58.	Ironstone	0	4	37	0
59.	Grey clunch	7	0		

		FT.	IN.	FT.	IN.
60.	Black batt	0	6		
61.	Strong binds	3	0		
62.	Ironstone of inferior quality	0	2		
63.	Strong binds	6	0		
64.	Ironstone of inferior quality	0	3		
65.	Dark clod	2	2		
66.	Ironstone of inferior quality	0	2		
67.	Dark clod	1	11		
68.	Ironstone	0	1		
69.	Dark clod	2	3		
70.	Coal, Bentley Hey, half inferior quality	-	-	3	0
71.	Dark fire-clay	4	0		
72.	Grey fire-clay	4	6		
73.	Strong binds	5	0		
74.	Black batts	0	2		
75.	Black rock	0	6		
76.	Grey fire-clay	1	8	26	0
77.	Grey rock	8	0		
78.	Grey fire-clay	2	0		
79.	Ironstone	0	1		
80.	Dark clunch	0	6		
81.	Coal (? Heathen)	-	-	1	0
82.	Dark fire-clay	0	5		
83.	Dark rock	4	4		
84.	Peldon	1	2		
85.	Dark rock	2	4		
86.	Dark clunch	2	9		
87.	Strong batt	1	4		
88.	Dark clunch	3	0		
89.	Black batt	0	6		
90.	Grey rock	10	0		
91.	Peldon	3	0		
92.	Rock	3	0		
93.	Grey clunch	5	0		
94.	Hard grey rock	9	0		
95.	Strong binds	30	0		
96.	Grey fire-clay	9	0		
97.	Ironstone of inferior quality	0	1		
98.	Dark fire-clay	1	0	132	6
99.	Black batts with one 4 in. ball of ironstone	2	0		
100.	Fire-clay	1	0		
101.	Grey clod	4	0		
102.	Blue binds	5	0		
103.	Dark binds	8	0		
104.	Light rock	3	0		
105.	Dark binds	6	0		
106.	Peldon	1	0		
107.	Clod, supposed to be the New Mine ironstone clod, but not here containing workable ironstone	1	2		
108.	Ironstone	0	2		
109.	Dark clod	3	0		
110.	Ironstone	0	3		
111.	Measures, supposed to be those of the Pennystone ironstone, but not gettable	12	0		

	FT.	IN.	FT.	IN.
112. Coal. Sulphur Coal, the equivalent of the Top or Two-foot coal of the Brown Hills - - - - - -			1	2
113. Fire-clay - - - - - -	2	0	2	0
			202	8
Adding the upper part of the section - - -			302	9
We get a total of - - - - - -			505	5

(*See Vertical Sections, sheet* 16, *No.* 3, *and sheet* 26, *No.* 39.)

It will also be advisable to give here in detail the section of Mr. Mills' Engine pit at Essington Wood (communicated by Mr. Becket, and now engraved in Vertical Section sheet No. 26, section No. 38), and follow that with abstracts of some other sections from the neighbourhood of Wyrley.

Section of Mr. Mills's Engine pit at Essington Wood.

	FT.	IN.	FT.	IN.
1. Red clay and sand } Drift - -	12	3	18	3
2. Yellow clay - }	6	0		
3. Blue clay - - -	2	6		
4. Fire-clay - - - -	2	0		
5. Rock - - - - -	11	6		
6. Blue clunch - - - -	3	6		
7. Batt and Coal - - -	2	0		
8. Dark ground - - - -	1	0		
9. Fire-clay - - - -	12	0		
10. Parting - - - -	0	2		
11. Fire-clay with stone (ironstone) -	5	7	69	11
12. Black parting - - -	1	0		
13. Fire-clay - - - -	6	0		
14. Parting - - - -	0	8		
15. Fire-clay - - - -	3	7		
16. Dark ground - - - -	3	0		
17. Fire-clay - - - -	3	0		
18. Black parting - - - -	0	9		
19. Coal - - - - -	1	9		
20. Dark ground with ironstone - -	9	11		
21. Coal - - - - -	2	8		
22. Parting - - - -	0	9		
23. Coal - - - - -	3	0		
24. Parting - - - -	1	0		
25. Coal - - - - -	0	9	12	5
26. Parting - - - -	1	3		
27. Coal - - - - -	0	9		
28. Parting - - - -	1	6		
29. Coal - - - - -	0	9		
30. Dark ground - - - -	3	0		
31. Coal - - - - -	1	2		
32. Fire-clay - - - - -	21	0		
33. Strong clunch, intermixed with peldon	18	9	70	5
34. Strong clunch - - -	7	0		
35. Dark ground - - - -	2	0		
36. Fire-clay - - - - -	17	6		

		FT.	IN.	FT.	IN.
37.	Coal and batt	-	-	2	1
38.	Fire-clay and batt	6	0		
39.	Clunch	11	0		
40.	Dark binds	6	0	32	6
41.	Clunch	5	6		
42.	Dark clod	4	0		
43.	Coal	3	0		
44.	Parting	0	2	7	6
45.	Coal	4	4		
46.	Strong fire-clay	5	6		
47.	Strong light rock	8	8		
48.	Dark binds with rock	13	5		
49.	Peldon	2	6		
50.	Light binds with rock	9	0		
51.	Strong dark ground	4	0	57	3
52.	Coal	0	10		
53.	Strong dark clod	6	3		
54.	Strong dark clod, intermixed with ironstone	7	1		
55.	Old Robins Coal (of Wyrley) — Coal	1	0	5	8
	Parting	0	2		
	Coal	4	6		
56.	Strong batt	1	8		
57.	Dark clunch	4	0		
58.	Little Coal	0	7		
59.	Fire-clay	0	6		
60.	Strong dark ground, with ironstone	2	11	34	7
61.	Strong mixed ground	3	0		
62.	Grey binds	10	6		
63.	Strong dark clod, with ironstone	3	5		
64.	Strong dark ground	8	0		
65.	Yard Coal (of Wyrley) — Coal	3	0	5	0
	Parting	0	6		
	Coal	1	6		
66.	Fire-clay	1	6		
67.	Light binds	12	6		
68.	Parting	0	4		
69.	Fire-clay	1	8		
70.	Little Coal	0	9		
71.	Fire-clay	7	0		
72.	Grey binds	6	10	49	10
73.	Light rock, with black partings	6	9		
74.	Little Coal	1	3		
75.	Strong fire-clay	6	0		
76.	Light rock	1	3		
77.	Grey binds	3	2		
78.	Dark clod	0	10		
79.	Charles Coal (of Wyrley)	-	-	2	3
80.	Fire-clay	5	0		
81.	Grey binds	5	0	29	8
82.	Light rock	0	10		
83.	Grey binds	18	10		
84.	Cannel Coal (of Wyrley)	-	-	3	9

		FT.	IN.	FT.	IN.
85.	Strong dark ground	6	0		
86.	Peldon	1	0		
87.	Parting	0	8		
88.	Strong dark batt	4	0		
89.	Parting	0	6	57	3
90.	Strong dark batt	6	4		
91.	Light binds	31	9		
92.	Rock	7	0		
93.	Brooch Coal (of Wyrley)	2	2		
94.	Dark ground	3	6	6	3
95.	Coal (? Benches of Wyrley)	0	7		
96.	Light binds	20	5		
97.	Strong rock	7	0		
98.	Coal (not known at Wyrley)	2	0		
99.	Parting	1	3	73	10
100.	Strong light binds	19	2		
101.	Ditto with ironstone	20	3		
102.	Light binds	3	9		
103.	Bottom Coal of Wyrley: Coal	5	6		
	Parting	0	7	8	7
	Coal	2	6		
104.	Various measures	-	-	38	0
105.	Four Foot Coal	-	-	4	0
				589	0

(*Vertical Sections, sheet* 26, *No.* 38).

The following are the abstracts of some other Wyrley sections:—

Section at Longhouse.

	FT.	IN.	FT.	IN.
1. Red sandy rotch, perhaps part of New Red sandstone	35	6	–	
2. Alternations of clunch, grey rock, and black batt	101	0	–	
3. Coal and batt	-	-	1	9
4. Rock and clunch	10	0	–	
5. Coals and partings, principally batts	-	-	5	10
6. Dark clunch	1	11	–	
7. Coal	-	-	2	0
8. Fire-clay, clunch, and rock	74	0	–	
9. Coal (Old Robins coal)	-	-	6	6
10. Various measures	84	0	–	
11. Coal (probably the Charles coal)	-	-	3	0
12. Various measures	54	0	–	
13. Coal (Cannel coal)	-	-	3	6
14. Various measures	81	0	–	
15. Coal (Brooch and Benches)	-	-	7	
16. Various measures	48	0	–	
17. Coal (called Bottom coal)*	-	-	7	0
	489	5	36	7
	36	7		
	526	0		

* In several parts of the Wyrley field there is in the Bottom (or Deep) coal what is known to the colliers as the Middle batt or parting. This is always found, but

*Section of Mr. Gilpin's new pits between Church Bridge and Wyrley Bank.**

			FT.	IN.	FT.	IN.
1.	Clay, shale, &c.		30	0	–	
2.	Robins coal		–	–	8	0
3.	Black batts, with ironstone balls		22	0	–	
4.	Yard coal		–	–	3	0
5.	Fire-clay, batt, and binds		69	0	–	
6.	Charles coal		–	–	3	0
7.	Binds and rock		64	0	–	
8.	Cannel coal		–	–	4	0
9.	Binds, &c.		84	0	–	
10.	Brooch coal		–	–	4	0
	Rubbish (7 3)		1	0	–	
11.	Benches coal		–	–	2	3
12.	Binds, &c.		40	0	–	
13.	Bottom coal		–	–	8	0
14.	Binds, &c.		39	0	–	
15.	Another coal		–	–	3	0
			349	0	35	3
			35	3		
			384	3		

Section of Mr. Gilpin's pits near the Cock public-house.

				FT.	IN.	FT.	IN.
1.	Soil and clay			13	6	–	
2.	Clunch and batt, with ironstone			6	7	–	
3.	Old man's coal = Yard coal			–	–	3	9
4.	Fire-clay, batt, and clunch, with grubb ironstone	19	6	35	6	–	
5.	Flying coal	1	0				
6.	Fire-clay, binds, &c.	15	0				
7.	Charles coal			–	–	2	4
8.	Fire-clay and clunch	15	6	54	0		
9.	Flying coal	3	0				
10.	Fire-clay, binds, and clunch	35	6				
11.	Cannel coal			–	–	3	11
				109	7	10	0
				10	0		
				119	7		

varies in thickness in different pits from 18 to 21 inches, undulating considerably in short distances. In one pit this batt is represented by a very hard rock four inches in thickness, very fine in the grain, and of a greyish white colour.—*Note by Mr. Gilpin.*

* Given me by Mr. Gilpin, and Jesse Potts, his ground bailiff.

*Section at Mr. Yates' colliery at Wyrley.**

					FT.	IN.	FT.	IN.
1. Soil and gravel	-	-	-		12	0		
2. Clunch and binds	-	-	12	0				
3. Flying coal	-	-	1	0	35	6		
4. Fire-clay and rock	-	-	22	6				
5. Charles coal	-	-	-		-	-	3	0
6. Fire-clay and clunch	-	-	12	0				
7. Flying coal	-	-	1	6	40	9		
8. Fire-clay, binds, and rock		-	27	3				
Cannel coal	-	-	-		-	-	3	8
					88	3	6	8
					6	8		
					94	11		

Relation of the Coals, &c. of Wyrley and Essington to the Red coal-measure clays.—We might look upon the red measures in the upper part of the Longhouse section as being the bottom of the Red clays of the coal-measures, if it were not for the fact that they come in at a height of only 168 feet above the Old Robins coal, while in the Essington colliery there is a thickness of 252 feet of true coal-measures over that coal, with beds of coal and clunch and fire-clay throughout, and without the appearance of any red clays except those which are undoubtedly superficial or drift materials. It is probable then that the red beds at Longhouse belonged to the New red sandstone, and that the shaft was sunk through the boundary fault which inclined obliquely across it.

We have, therefore, here no means of determining exactly the height above the Old Robins or other of the Wyrley and Essington coals at which the Red coal-measure beds ought to make their appearance in the section. But as the beds in the Essington colliery dip at a gentle angle in the direction of the south-west extension of the Red clays in the Essington Wood brick pits, it is probable that the uppermost beds of Essington colliery would be covered by the Red clays about half way between the two places, and without any very large increase of thickness, not more, perhaps, than 100 feet or thereabouts.

If this be true, the Essington and Wyrley coals may be expected to lie at no very unreasonable depth beneath the Red clays of the Essington Wood brick pits, and over all the space up to the boundary fault as drawn in the latest edition of our maps (that of 1859).

The Red coal-measure clays, however, are worked on the eastern side of the district about Walsall Wood as well as on the west side near Essington, and have beneath them coals which are now being worked. Let us therefore examine,

The relations between the Red coal-measure clays of Walsall Wood and the Coal-measures of Coppy Hall Colliery and the Aldridge Trial Pit.—The Red clays about Walsall Wood and the neighbourhood have long been extensively opened by brick pits. Their general dip is northerly at very slight angles, not more than 3°. A shaft has now been lately sunk through a considerable thickness of these clays south of all the brick pits, and where, therefore, they are probably thinner than

* The two latter sections were given me by Mr. George, of Bentley.

at any locality further north. It was undertaken by the Rev. Baily Williams, whose enterprise has been deservedly rewarded by the discovery of several good coals and some ironstone below them. This pit is called No. 1. of the Coppy Hall colliery, and is situated just over the "o" of "Stubbock's Green," as engraved on the Ordnance map. The following is an abstract of the measures passed through, communicated by Mr. Roberts, the mine agent, of Walsall :—

Section of Coppy Hall Colliery.

		FT.	IN.	FT.	IN.
1.	Red clay and marl, &c.	218	0	–	
2.	Green and red shales interstratified with dark grey and black measures	37	0	–	
3.	Coal			1	0
4.	Fire-clay, binds, &c., with one or two small coals	140	6	–	
5.	Coal, four small coals with partings			12	8
6.	Fire-clay, binds, &c. with ironstone balls	92	8	–	
7.	Coal, with batt			2	3
8.	Binds, with ironstone, rock, &c.	33	7	–	
9.	Coal			7	6
10.	Binds, with ironstone	11	0	–	
11.	Coal			1	0
12.	Binds, with ironstone, &c.	12	10	–	
13.	Coal			4	0
14.	Shales and binds, with ironstone	18	0	–	
		562	7	28	5
		28	5		
		591	0		

(*See Vertical Sections, sheet* 26, *No.* 44.)

There was a trial pit sunk about ten years ago, a little more than a mile to the southward of the Coppy Hall colliery, a little north of the Red House near Aldridge. As the measures hereabouts all dip to the north, or a little east of north, at an angle of 30°, the beds, which lie deep at Coppy Hall colliery ought, if there be no fault between the two places and the increase of dip take place gradually, to crop out at or about the Aldridge trial pit.

The following is an abstract of the section of that pit, which was published by Mr. Roberts in the year 1849 :—

Abstract of the Measures passed through in the Aldridge Trial Pit.

		FT.	IN.	FT.	IN.
1.	Upper measures	55	0	–	
2.	Coal and batt			2	9
3.	Fire-clay and clod	18	3	–	
4.	Coal and batt			1	9
5.	Fire-clay, clod, and binds	10	9	–	
6.	Coal and batt			4	6
7.	Fire-clay, binds, &c.	86	6	–	
8.	Coal and batt			3	6
9.	Fire clay, &c., with small ironstone	31	7	–	
10.	Coal with parting			7	8

		FT.	IN.	FT.	IN.
11.	Fire-clay, binds, with good ironstone, &c.	18	6	–	
12.	Coal	–	–	1	0
13.	Ironstone measures, fire-clay, &c.	17	4	–	
14.	Coal	–	–	5	10
15.	Fire-clay, rock, and binds, with ironstone, &c.	61	4	–	
16.	Coal	–	–	6	6
17.	Fire-clay	2	9	–	
18.	Coal	–	–	1	0
19.	Fire-clay, clod, &c.	16	8	–	
20.	Coal	–	–	3	4
21.	Various measures	77	9	–	
		399	5	37	10
		37	10		
	Total	437	3		

(*See Vertical Sections, sheet* 16, *No.* 4.)

It would be very unsafe to draw conclusions from a mere resemblance in the thicknesses and grouping of beds in two sections more than a mile apart, but looking both to the fact of the occurrence of ironstone, and the near agreement in thickness, it seems very probable that the bed numbered 13 in the Coppy Hall section, is the same as that numbered 14 in the Aldridge trial pits. The resemblance is very striking, if we place side by side the following parts of the two sections :—

	Coppy Hall.		Aldridge.	
	No.	Thickness.	No.	Thickness.
		FT. IN.		FT. IN.
Fireclay, Binds, &c.	6	92 8	7	86 6
Coal with batt	7	2 3	8	3 6
Binds and fire-clay with ironstone	8	33 7	9	31 7
Coal	9	7 6	10	7 8
Binds and fire-clay with ironstone	10	11 0	11	18 6
Coal	11	1 0	12	1 0
Binds, &c. and ironstone measures	12	12 10	13	17 4
Coal	13	4 0	14	5 10

Over No. 6 in the Coppy Hall shaft there are several coals and batts with partings, while over No. 7 of Aldridge there are likewise some small coals and bats, separated, however, not by mere partings, but by groups of beds, though not of large thickness, these being surmounted by 55 feet of various measures, which may very well be the lower part of the 140 feet of measures grouped as No. 4 in the Coppy Hall colliery. In this case the beds which reached the surface at the Aldridge shaft would be about 340 feet deep at the Coppy Hall colliery.

If we might be permitted to extend our comparison from the eastern to the western side of the coal-field, and to suppose that the small coals and batts which are numbered 2 to 6 inclusive in the Aldridge section, and those marked No. 5 in the Coppy Hall section were the same group, there or thereabouts, as the group of small coals and partings numbered as No. 20 to 29 in the Essington section, given at page 94, we should

find a very great resemblance in the thicknesses of the beds immediately below them, as follows :—

	Aldridge.	Coppy Hall.	Essington.
1. Small coals and partings -	38 0	12 8	12 5
Intermediate -	86 6	92 8	70 5
2. Coal and batt -	3 6	2 3	2 1
Intermediate -	33 7	31 7	32 6
3. Coal and partings	7 8	7 6	7 6
Intermediate -	36 10	24 0	57 3
4. Coal and partings	5 10	4 0	5 8

If the above be anything more than an accidental coincidence, and we may really believe that the measures are the same beds in the three places, it would then follow that, as the fourth or lowest coal just mentioned at Essington is the Old Robins coal, the coal No. 13 of Coppy Hall, and that No. 14 of Aldridge is also the same as the Old Robins coal of Wyrley. Mr. Gilpin, of Wyrley, on the other hand, is of opinion that the ironstones over coal No. 16 of Aldridge and below coal No. 13 of the Coppy Hall section are the same ironstones as those just above the Bottom coal of Wyrley. If that be so, then coal No. 16 of the Aldridge section, p. 100, is the Bottom coal of Wyrley, No. 20 probably the Bentley Hey coal, No. 14 probably the Wyrley Brooch and Benches, No. 10 the Cannel, No. 8 the Charles, and No. 6 the Yard coal. In the Coppy Hall pit then, No. 13 must be the Brooch and Benches, No. 11 the Cannel, No. 9 the Charles, No. 7 the Yard, and No. 5 the Old Robins. If this be so, there is a very wide discrepancy in the thickness of the measures in the two sides of the coal-field, and a still greater one in the thickness between the base of the red clays and the Old Robins coal. If No. 5 of the Coppy Hall pit represent the Old Robins of Essington, we have only about 180 feet between it and the red clays there, while at Essington there is 252 feet without the appearance of any red clays, and they are probably at least 30 or 40 feet higher, perhaps 100 feet. Whatever may be the value of these identifications of particular beds, we may feel pretty sure that the beds at Coppy Hall and the Aldridge trial pits are on about the same geological horizon as the upper coals of Essington and Wyrley, and that all the other Wyrley coals will probably be found eventually below them, as well as the Brown Hills and Pelsall beds at a still lower depth.

If this comparison of the measures on the two sides of the coal-field be right, it follows that as the coal No. 13 of the Coppy Hall colliery lies at a depth of about 280 feet below the base of the red clays there, that is the probable position at which the Old Robins coal may lie below them at Essington Wood, and that as in the pits, of which the section is given at p. 94, it is 252 feet deep, if that pit had been sunk a little farther on the dip of the beds, the Red coal-measure clays would have appeared in the top of it.

A further consequence of this hypothesis would be that as the place of the Deep coal of Pelsall and the Brown Hills is about 650 feet below the Old Robins coal of Wyrley, it is also about that much under the coal No. 13 of Coppy Hall and No. 14 of Aldridge, and must, therefore, be about 1,200 feet below the surface at Coppy Hall ; we should hence get a rough measure for the amount of the fault, which brings in the upper red coal-measure clays of Walsall Wood to the eastward of the outcrop of the Deep coal on Pelsall Heath, for it is obvious that it must have a downthrow to the eastward of considerably more than 1,000 feet.

It is by no means wished to put forward these statements of figures as absolutely trustworthy or exact, still a fault which brings in those

Upper Red clays that lie above all the workable coal-seams of the field and are apparently the same as those which are known to lie 100 yards above the Thick coal, and places these Upper clays on a level and in close juxtaposition with the very base of the coal-field must have a throw of something about that amount. That these Upper Red beds are in reality upper Coal-measures is confirmed by all the beds being apparently quite conformable to each other, and the black and red measures graduating into each other at the Coppy Hall colliery.

It would follow from this that workable beds of coal lie at no inaccessible depth over all the corner of ground about Walsall Wood and Clayhanger, and may be reached after passing through from 300 to 600 feet of the red clays.

The same will be true also for the red brick clays of Essington Wood and the strip of country north and south of it, where these clays prevail; as also for the red clays of Rumour Hill east of Cannock and those of Littleworth near Hednesford, although near Cannock it is probable, from Mr. Gilpin's account, that the ground is too much cut up by faults to make exploration other than very hazardous.

The Cannock Chase District.—It has been already stated that the dip of the measures all across the part of the coal-field now being treated of is from east to west. In the northern part of the Brown Hills field, however, the beds are beginning slightly to curve round, so as to strike to the north-east and dip to the north-west. It is probable then that the beds all across the field will follow this curve, and that the Wyrley coals will curve round from Church Bridge and strike towards the north-west in the direction of Brereton.

This probability is confirmed by the fact of two outcrops of coal being still traceable in Cannock Chace by means of some old workings having this bearing. The one outcrop runs from about Heathy Hays to near Cooper's Lodge, as was formerly observed by myself. Another was traced by the persons employed by the Commissioners who divided the mines of Norton Manor. Mr. Beckett, of Wolverhampton, who was associated with these persons, has allowed me to examine the plans and reports which were drawn up.* This outcrop runs from a little north of Norton Church on to Norton Common, and it is stated in the report above alluded to that it was the opinion of the reporters that this coal was the same as the Bentley Hey coal, or that four-foot coal which lies next below the Wyrley (so called) Bottom coal.

We may perhaps be justified in looking on this outcrop at Norton as more probably that of the Eight-foot or Wyrley Bottom coal itself, and that the Bentley Hey coal crop will be found still further to the south-east, especially when we remember the existence both of the Bentley Hey coal and the Heathen coal in the pit of the Cathedral colliery, which lies in the trough of the Rising Sun 2 miles to the south-east.

Now, with the lower coals undoubtedly at the Brown Hills, the upper coals a little south of Cannock, and these traces of the middle beds half way between, we may feel pretty sure that we should have the whole workable and valuable part of the coal-field cropping out in regular succession from west to east along the line of Watling Street between the two boundary faults. The distance along the ground is about 4½ miles, say 24,000 feet, and the total thickness of the measures as presumed from the section given at p. 23, will be about 1,000 feet. This will give a mean inclination of about 1 in 24 or not quite 3°, which

* It was from this detailed survey that the information was gained that enabled Professor Ramsay to introduce into the map the faults in the neighbourhood of Norton reservoir, and correct some of my former work which was based upon imperfect and often erroneous information.

agrees very closely with the observed inclination in all the workings of the mines.

It is then highly probable that the whole of the Coal-measures will sweep pretty steadily across Cannock Chase up to Brereton.

Old shallow workings have been carried on here and there about Cannock Chase, of which the following records were formerly gained and published in the first edition of this Memoir.

At Cannock mill, just east of Cannock, there were some coal-pits a few years back worked by Lord Hatherton, and called the Rumour Hill pits, of which I got the following section from the recollection of Abraham Ward, well-sinker, at Cannock :—

	FT.	IN.	FT.	IN.
1. Red marl	6	0	–	
2. White binds	12	0	–	
3. Cannel coal	–	–	3	6
4. Bind measures	24	0	–	
5. Rock	3	0	–	
6. Two-foot coal	–	–	2	0
7. Binds, rock binds, clunch, &c.	72	0	–	
8. Coal	–	–	4	6
9. Measures	90	0	–	
10. Stinking coal	–	–	5	0
	207	0	15	0
	15	0		
	222	0		

We cannot with any degree of certainty identify any of these beds with any of those at Wyrley, but Mr. Gilpin believes them to belong to the upper Coal-measures of Wyrley.

Just south of the hamlet of Hednesford there are some old coal workings, of which I got the following section from W. Haycock, an old collier at Brereton :—

	FT.	IN.	FT.	IN.
1. Gravel	20	0	–	
2. Clod	12	0	–	
3. Yellow rock	42	0	–	
4. Clod	10	0	–	
5. Coal	–	–	7	0
6. Clod containing good ironstone	90	0	–	
7. Coal	–	–	4	0
	185	0	11	0
	11	0		
	185	0		

Some new shafts were being sunk by Mr. Piggott just to the eastward of Hednesford, in the year 1858, in which they had found what they believed to be the Wyrley Bottom or Eight-foot coal at a depth of 300 feet. It was there only 6 foot thick, and 60 feet below it there was a Four-foot coal, which might possibly be the Bentley Hey coal, while 90 feet over it, or at a depth of 210 feet from the surface, there was another coal of 4½ feet thick, believed to be the Wyrley Cannel coal. They had also got the black nodular ironstone full of tubular cavities, from which at Wyrley it is called the Grub ironstone.

On the authority of W. Haycock, the measures at the old Botany Bay colliery, just north-west of Hednesford Pool, were,—

	FT.	FT.
1. Running sand	51	–
2. Clod	29	–
3. Coal	–	5
4. Clod	20	–
5. Coal	–	3
	180	8
	8	
	188	

The same person also gave me the following scraps of information:—

Section between Heathy Heys, Wimblebury, and Cooper's Lodge.

	FT.	IN.
1. Gravel	12	0
2. Clod	90	0
3. Cannel coal	1	4
4. Clod	6	0
5. Coal	4	0
	113	4

Section between Sugars Lodge and Lodge Barn in Beaudesert Old Park.

	FT.	IN.
1. Waterclay	6	0
2. Clod	60	0
3. Coal	5	0
Under which they bored down through many measures containing 9 coals	360	0
	431	0

He also told me that, at Noddyfield, near Mr. Cocking's house, there was the same section as at Hednesford, the seven-foot coal being 51 feet deep at Noddyfield, instead of 84, as at Hednesford. As Noddyfield is much higher ground than Hednesford, there must, if this information be correct, probably be a gentle westerly or north-westerly dip over all the intervening space.

I procured an old section from the late Mr. Figgins, of Brereton Heys, mine agent to the Marquis of Anglesea, which was taken either at Noddyfield, or in the Old Park of Beaudesert, most probably the former. In either case it does not go greatly against W. Haycock's evidence, and in the latter tends to confirm it.

The following is an abstract of this section :—

	FT.	IN.	FT.	IN.
1. From surface to the bottom of a coal of which the thickness is not stated	90	0	–	
2. Clunch, binds, fire-clay, rocks, &c., with three little nine-inch or foot coals intervening	70	6	–	
3. Coal	–		4	0
4. Rock, binds, &c.	25	6	–	
5. Coal	–		2	0
6. Fire-clay, binds, rock, clunch, &c.	39	0	–	
7. Coal	–		4	0
8. Fire-clay	0	0	–	
	225	0	10	0
	10	0		
	235	0		

This section evidently passes through the same measures as those which are now being worked near Brereton, about three miles to the northward.

The Brereton Collieries.—Of the pits in the Brereton colliery district I have had sections supplied to me by Mr. George, of Bentley; Mr. Vernon Poole, of Brereton, Lord Talbot's agent; and by the late Mr. Figgins. These sections are so nearly identical that they seem all to have come from the same source, and to apply equally to all the Brereton district. The section now engraved in Vertical Sections, Sheet 16, No. 1, will give the details, but I add here an abstract:—

Brereton Section.

		FT.	IN.	FT.	IN.
1.	Red and white gravel (part of the New red sandstone conglomerate)	80	0	–	
2.	Red and yellow marl, rock, clod, and batt	16	6	–	
3.	First coal	–		4	6
4.	Clod with ironstone	19	10	–	
5.	Second coal	–		2	6
6.	Clod and rock	51	3	–	
7.	Third coal	–		2	0
8.	Fire-clay and clod	13	0	–	
9.	Fourth coal	–		4	0
10.	Rock clod and ironstone	30	1	–	
11.	Fifth coal	–		4	0
12.	Fire-clay	3	0	–	
13.	Sixth coal	–		0	4
14.	Rock with ironstone	14	8	–	
15.	Seventh coal	–		2	3
16.	Rock with ironstone, and clod and batt	36	0	–	
17.	Eighth coal	–		4	0
18.	Batt, clod, and light rock and clod	50	0	–	
19.	Ninth coal	–		0	6
20.	Clod, &c.	6	0	–	
21.	Tenth coal	–		3	3
22.	Rock	13	4	–	
23.	Eleventh coal	–		1	0
24.	Clod, rock, and ironstone, &c.	22	10	–	
25.	Twelfth coal	–		9	0
26.	Rock, binds, and ironstone	48	7	–	
27.	Coal, not enumerated	–		2	0
28.	Binds with ironstone	21	7	–	
29.	Thirteenth coal	–		5	0
30.	Fire clay and clod	24	0	–	
31.	Fourteenth coal	–		1	0
32.	Rock, clod, and ironstone	105	8	–	
33.	Fifteenth coal	–		4	3
		556	4	49	7
		49	7		
		605	11		

(*See Vertical Sections, sheet* 16, *No.* 1.)

Below the fifteenth coal they sank some distance in red measures.

It will be at once seen from the inspection of this section that it is not possible, from the mere thickness and relative position of its beds, to

discover any relation between it and any of those we have examined in the southern part of the field. Everything, however, seems to confirm the conclusion formerly arrived at, that, speaking generally, the Brereton coals are the same as the Wyrley coals, a little more split up and separated from each other. It is remarkable, too, that the total amount of the Brereton coals, when added together, namely, 49 feet, is nearly the same with their total amount at Wyrley, namely, 46 feet.*

The Lickey Coal-measures.—Before closing the account of the Coal-measures it is necessary just to mention two little outlying districts of that formation on the south of the field,—one is near the Lickey Hill, where small patches of Coal-measures with one or two little bands of coal were found on each side of the quartz ridge, near the New Rose and Crown.

The Stonehouse Coal-measures.—Another is near the Stone House, south-west of Harborne. At this latter locality Mr. Flavell sank 240 feet through true Coal-measures, grey shales, with nodules of ironstone, but without traversing any bed of coal. It is obviously impossible to say what part of the general series of Coal-measures those found at these two localities belong to.

CHAPTER VII.

Description of the Rocks—*continued.*

5. *The Silurian Rocks.*

Of the Silurian formation we have, in or near the South Staffordshire coal-field, parts of three different subdivisions:—

1st. A portion of the Ludlow rocks containing a band of limestone, believed to be the same as the Aymestry limestone.

2nd. The Wenlock and Dudley rocks entire.

3rd. A portion of the Llandovery (formerly considered part of the Caradoc) sandstone.

These rocks have been so fully described by Sir R. I. Murchison in his "Silurian System" that there remains but little to say respecting them.

Ludlow and Sedgley rocks.—The mass of the Ludlow and Wenlock rocks, or, as they might here be called, the Sedgley and Dudley rocks, consists of a brown or blueish grey argillaceous shale, always very smooth and compact, thick-bedded and regularly jointed. In the upper portion is a band of dark brown nodular and concretionary limestone, some 20 or 25 feet in thickness. It is locally called the "Brown lime." From its containing the *Pentamerus Knightii*, and other fossils, and from its position, it is with great probability identified with the Aymesy limestone. This limestone shows itself at Sedgley, at Turner's

* Near Dudley, the total amount of all the coals would be about 57 feet. The richest part of the field in amount of coal-beds, both absolutely and still more in proportion to the whole thickness of the measures in which they lie is between Wolverhampton and Bilston, where the lower coals are becoming rapidly thicker, and the Thick coal is still nearly unbroken and undiminished. The total amount of the coals in a vertical section there would in some places be upwards of 70 feet, all within a depth of about 300 feet from the surface.

Hill, and at the Hayes near the Lye Waste, 2 miles east of Stourbridge.

At a certain depth below this, is the Wenlock and Dudley limestone, which is locally called "White lime."

What is the exact thickness intermediate between these two limestones, or how far they were vertically apart at their period of deposition, we have no means of determining. In the only place where they both crop to the surface in one area, namely, at Sedgley Beacon and Hurst Hill, a fault runs between the two which has been traced on one side in the workings, but without arriving at any means of determining the amount of its "throw." I have, however, assumed 800 or 1,000 feet as the vertical distance between the limestones. This thickness enabled me to draw the sections, with the least amount of dislocation and disturbance, of which there was no decided evidence; but I feel by no means confident that that thickness ought not to be either diminished or increased.

There is no lithological distinction between the shale or bavin above the Dudley limestone and that below it, but the one above is assumed to belong to the Ludlow group, and that below it to the Wenlock.

Wenlock and Dudley rocks.—The Wenlock and Dudley limestone forms two bands of solid concretionary and flaggy limestone, with many calcareous nodules, concretions, and small flaggy beds, both between, above, and below them.

At Dudley, we have the two following sections of the limestone given in the Silurian System:—

The Castle Hill.	FT.	IN.
Upper limestone or thin measures	23	1
Intermediate shale	—	
Lower limestone or thick measures	35	7

The Wren's Nest.	FT.	IN.
Upper limestone	28	4
Intermediate shale	90	0
Lower limestone	42	3

At Hurst Hill, the beds are collectively thinner and the limestones closer together. At Mr. Bagnall's limestone pits at Dudley Port they found two bands of limestone,—upper, 27, and lower, 24 feet thick,—resting directly one on the other. At Mr. Giles's pit, however, according to Sir R. I. Murchison, the limestone worked was 21 feet thick, and they reached, by boring, another mass of limestone 150 feet below it. At Deepfield's, a little east of Hurst Hill, according to "Smith's Miner's Guide," they sank below the Coal-measures through 150 feet of blue rocky clunch, probably Silurian shale, and then came on limestone in about ten beds of nearly 3 feet each.

In the neighbourhood of Walsall the Dudley and Wenlock limestone consists of—

	FT.
Thin or upper limestone	12
Intermediate shale, &c.	120
Thick or lower limestone	34

The following more detailed section of these beds has been furnished by Mr. Beckett, of Wolverhampton, who procured it from Mr. B. R. Smith, of Walsall:—

			FT.	IN.	FT.	IN.
1.	Surface matter, Diamonds ironstone grit rock, and Flying reed limestone binds		61	4	–	
2.	The Four-yard stone, first thick band of limestone				12	0
3.	Mush, clunch, &c.		108	6	–	
4.	Covering Burr, not gettable	1 6				
5.	Burr	1 8				
6.	Thick Burr	3 3				
7.	Chattering Burr	1 0				
8.	Chippers	3 3				
9.	Captain	1 0				
10.	Seven floors	1 8				
11.	Fourth shot	1 6	Thick limestone		34	2
12.	Third shot	1 0				
13.	Strong stone	3 0				
14.	Yellow clay floor	0 10				
15.	Flints	2 9				
16.	Half yard measure	1 6				
17.	Bell flag	2 3				
18.	Knotty floor	2 0				
19.	Thick floor	3 8				
20.	Rottens	2 4				
21.	Clunch		8	0	–	
			177	10	46	2
			46	2		
	Total		224	0		

At Hobbs Hole, a little east of Darlaston, the Silurian rocks lying below the Coal-measures have the following composition, according to the information of Mr. Smallman:—

	FT.	IN.	FT.	IN.
From surface to bottom of Heathen coal	15	0	–	
From that to bottom of Coal-measures	292	6	–	
	307	6		
Limestone shale			60	0
THIN LIMESTONE			16	6
Limestone shale			90	0
THICK LIMESTONE			30	0
	307	6	196	6

In this neighbourhood (Walsall) the Dudley limestone crops out at a gentle angle, and the lower shale rises from underneath it, spreading out to the east over a tract nearly 2 miles in width, till another band, known as the Barr limestone, rises to the surface at Hay Head, near Great Barr. There is but little to be seen in

the space between those two limestones, but where seen, as in the cutting of the new canal that runs from Hay Head to the Tame Valley, the shale was always found in a nearly horizontal position.

At the Hay Head quarries the Barr limestone rises from beneath the shale at an angle of about 8° or 10° on an average. Drawing the section from these data, the Barr limestone will probably lie at a depth of about 500 or 600 feet below the Dudley limestone, though it may easily be more.

In mineral character, the Barr limestone much resembles that of Woolhope* in Herefordshire, which lies at the junction of the Wenlock and Llandovery rocks, and it may very easily be at or near the actual base of the Wenlock rocks as they exist in Staffordshire. In this case we ought to have the Llandovery sandstone rising out immediately to the east of the Barr limestone.

In the former edition of this Memoir I stated that there was no appearance of this sandstone from underneath the Barr limestone, or below the base of the Wenlock rocks, in the neighbourhood of Great Barr or Hay Head, as I thought I had examined every place where it could appear and had not found it.

The late Mr. Daniel Sharpe, however, called my attention to a quarry of it, which had escaped my notice, in consequence of its small size, and its being situated under a steep bank, overgrown with brambles and nettles, at the side of a field in which, when I visited it, the wheat was high and in full ear.

Llandovery sandstone.—I revisited the locality in the year 1853 and was guided to the old quarry by Mr. George Eglinton, of Shustoke Lodge, who had himself pointed out the quarry to Mr. Sharpe.

In the ploughed field, which slopes gently up to the quarry, fragments of grey shale were observable on the ground with small cakes and concretionary flakes of limestone, like those described below as being found at the Colmers, near the Lickey.

It is probable that these are the representatives of the Barr limestone, which is very likely of partial occurrence, as an actual limestone, though thin calcareous courses may be found generally on its horizon. At the upper end of the field, under the hedge, was the small quarry. There was but a very small exposure of rock, not enough to show the dip of the beds, which, however, may be presumed to be the same as that of the other Silurian rocks of the neighbourhood, or about 5° to the west. The rock was a pale yellow or brown sandstone, in some places nearly white and purely quartzose, in others stained with ferruginous bands forming concentric rings. Other portions were calcareous, almost deserving the name of an arenaceous limestone. It was greatly jointed, splitting into sharp angular fragments.

Some parts of it were highly fossiliferous, and Mr. Salter determined the following species in the few blocks of the rock

* I state this on the authority of Professor Ramsay, who, on one occasion, accompanied me to Hay Head, and who was perfectly acquainted with the limestone of Woolhope, a district I never had the good fortune to visit.

I was able to carry away;* one or two more were brought by other observers.

Fossils in the Llandovery Sandstone, south-east of Shustoke Lodge.

Trilobites.

Encrinurus punctatus - - - -	4
Phacops caudatus - - - - -	1
„ *Stokesii* - - - - -	1
„ *truncato-caudatus?* - - -	1

Mollusca.

Chonetes lata? (probably only a *Leptæna*) -	1
Strophomena compressa - - - -	2
Atrypa reticularis - - - - -	6
Rhynchonella, 2 plaited sp. - - -	8
„ *Wilsoni* - - - -	20
„ small smooth species - -	50
Pentamerus liratus and *P. lens* - - -	2
Pterinea - - - - - -	1
Acroculia Haliotis - - - -	1

Crinoidea.

Periechocrinus moniliformis? stem joints -	30

Bryozoa and Corals.

Fenestella (with close meshes) - - -	1
Favosites alveolaris.	
Petraia bina.	

Mr. Eglinton also showed me just at the back of the house called Daffodilly at Hay Head, in a little deep ditch or gully overgrown with brambles, some beds of exactly similar sandstone, in which, however, we could find no fossils.

This was overlaid to the west, or in the direction of the old quarries of the Barr limestone, by Coal-measure shale containing a small two-foot coal, and cut off to the east by the Permian red marls, &c. North and north-east of it also Coal-measures containing small beds of coal had been found.

These Coal-measures, no doubt, rest unconformably on the upturned and denuded edges of the Silurian rocks, and it is quite possible that the Llandovery sandstone would be found under the greater part of those Coal-measures which spread over the space north-east of the Three Crowns Inn, between the outcrop of the Barr limestone and the Permian rocks which come in on the east side of the Boundary fault.

In the Lower Lickey Hills, between Birmingham and Bromsgrove, there is a ridge of quartz rock determined by Sir R. I. Murchison to be altered sandstone of this age. I can add little to the full and accurate description of this rock and neighbourhood

* See Journal Geol. Soc., Lond., vol. ix. p. 181, April 1853.

which is given in the "Silurian System," and shall, therefore content myself with the following quotations from it:—

"On first examining the tract in 1834, I observed, that at two points on its eastern and south-eastern flank (Colmers and Kendal End) the quartz rock was overlaid by a limestone and shale which contained some corals and shells of the Wenlock formation. At Kendal End, the solid limestone extracted, 23 years before, did not exceed a yard in thickness, but it was accompanied by small concretions called 'batch cakes.' The existence of another thin band of limestone was ascertained by sinking for coal at the Colmers." * * * "The sheds of coal and shale" * * * "were easily penetrated; and the sinkings were continued through a thin layer of impure limestone, only 13 inches thick, which, from its appearance and organic remains, I consider to be one of those calcareous courses which underlie the Wenlock shale, and form the top of the Caradoc ('Llandovery') sandstone (Woolhope limestone)." * * * "After penetrating this limestone, the coal speculators sunk till they were stopped by a hard quartzose sandstone and reddish slaty clay, similar to that which rises on the eastern flank of the quartz hills. Near the southern extremity of Snead's Heath, the cutting of a new road exposed a reddish siliceous sandstone, made up of rounded grains of quartz, containing casts of characteristic Caradoc ('Llandovery') fossils. These fossiliferous sandstones, having in themselves a half-fused appearance, form the upper portion of the true quartz rock of these hills, into which they graduate insensibly at Snead's Heath, so that it is impracticable to draw any defined line between the reddish fossiliferous sandstone and the quartz rock."

The little fragments of limestone or calcareous flags lying on the old spoil banks in the Long Wood near the Colmers, when I examined the ground, were precisely similar to those which I afterwards saw in the ploughed field at Shustoke Lodge. I have, therefore, now no doubt that those calcareous courses at the Colmers, as well as the band of limestone formerly worked at Kendal End at the south end of the Lower Lickey range are also the representatives of the Barr limestone, and that the shales in which they lie repose directly on the Llandovery sandstone. Sir R. I. Murchison, indeed, expressly says above, that after penetrating the limestone bands at the Colmers, the speculators were stopped by hard quartzose sandstone and slatey clay similar to that which rises near the eastern flank of the Quartz Hills (see Fig. 21).

The beds of quartz rock in the Lower Lickey range are tilted at high angles, and in some places much contorted, and the whole must have a thickness of 300 or 400 feet at least.

What influence it was that converted the rather soft sandstone that is to be seen at Barr into hard quartz rock at the Lickey we cannot exactly say, but as the quartz rock has apparently no other cement than a siliceous one, it seems impossible that dry heat could have effected it. If, moreover, there had been heat of a sufficient intensity to cause this alteration, it seems scarcely possible to conceive that the Wenlock shales and limestones should not have been equally effected.

We may, perhaps, be permitted to speculate on the possibility of hot springs having at some period burst out along the line of the Lower Lickey, the water having either itself contained silica in

solution, or having dissolved some of the silica of the sandstone and thus eventually cemented the grains together.

Note on the fossils; by J. W. Salter, Esq.

No traces of true Lower Silurian fossils occur in the district.

1. The fossils of the Bromsgrove Lickey have already been adverted to. It is sufficient to note that they are the common Llandovery or May Hill shells, such as *Pentamerus oblongus*, with *P. lens*, *Spirifer elevatus*, and a variety of *Orthis calligramma*, &c. They occur always as casts in the incoherent red grit, and are generally of full size. The fossils of the small patch of sandstone visible at Shustoke Lodge, near Barr, are also clearly referrible to the Upper Llandovery (or May Hill) zone. Among a number of Upper Silurian forms, such as the common species—

Phacops caudatus,	*Acroculia Haliotis*,
P. Stokesii,	*Periechocrinus moniliformis*,
Atrypa reticularis,	*Favosites alveolaris*, and
Rhynchonella Wilsoni,	*Petraia bina*,

we have the characteristic shell *Pentamerus lens*, a species never known to range out of the Llandovery rocks (*P. liratus* does rise into the Woolhope shales). This shell, with other fossils, was found here in plenty by Mr. J. E. Davis, after Mr. Sharpe had discovered the locality.

2. Woolhope Limestone.

The limestone of Hay Head, near Barr, has been generally regarded, from its position, as the equivalent of the Woolhope band, but there is not much palæontological evidence to prove this, except the occurrence of very large specimens of the *Illœnus* (*Bumastus*) *Barriensis*, for which well-known fossil it is the original locality.*

The following are found either there, at Ginity Graves, or at Daffodilly, on the same band:—

Calymene Blumenbachii; Phacops caudatus;
Strophomena depressa, S. pecten, S. imbrex, S. funiculata, S. euglypha, and *S. antiquata;*
Leptæna transversalis;
Obolus transversus; Orthis elegantula, O. biforata;
Atrypa reticularis, A. marginalis;
Spirifer elevatus, S. plicatellus;
Athyris tumida;
Rhynchonella nucula, R. deflexa, R. Grayii;
Pterinea (?) *planulata;*
Euomphalus discors, E. funatus;
Orthoceras annulatum.

With a few corals, such as—

Heliolites interstinctus;
Thecia Swindernana;
Favosites alveolaris (or *F. Gothlandica*);
Halysites catenularius—the chain coral;
Cyathophyllum truncatum, C. angustum;
Omphyma turbinatum (the largest of the Silurian cup corals);
Aulopora serpens, which is now found to be the creeping base of a *Syringopora* or tube-coral.

* See Magazine of Nat. History, vol. 2, p. 41, figs. 8, 9, 10, 1829.

It will be seen that this is a Wenlock Limestone list, and there are, indeed, few localities where the Woolhope band possesses any great distinctive character to separate it from the Wenlock. At Presteign, Radnorshire, it has, perhaps, the most peculiar facies. (See "Siluria," 2nd ed., p. 118.)

3. A few localities in the WENLOCK SHALE, such as the "Five Lanes" near Walsall, and the Bell in the same neighbourhood, are full of the characteristic fossils; a few are not known in the beds below. There are the ordinary brachiopod shells above mentioned, with *Strophomena imbrex* of Davidson, and *Obolus transversus;* the last is most abundant. This curious shell occurs also in the May Hill sandstone (but not of this district). *Pentamerus galeatus* and *Athyris tumida*, two or three species of *Pterinea*, especially the *Pt.* (?) *planulata*, which grows to a large size, *Cardiola striata*, a Lower Ludlow shell, *Acroculia Haliotis*, *Bellerophon*, *Phragmoceras pyriforme*, and a smooth *Orthoceras*, *Encrinurus punctatus*, and *Phacops caudatus*, are the common trilobites. *Ptychophyllum patellatum* and *Heliolites inordinatus* are conspicuous corals in the shale.

4. The WENLOCK LIMESTONE (divided into two bands by a thick layer of shale, as above described) contains all the fossils above noted, with the addition of a host of others. Indeed, the quarries of Dudley are the most famous in the world for Upper Silurian organisms. Shells, corals, encrinites of very numerous genera and species, and trilobites, are all in a state of perfection such as no other locality in Britain exhibits. The well known collections of Messrs. Gray and Fletcher at Dudley, and the cabinets of nearly every public museum in Britain or elsewhere, are evidences of the great labour expended in collecting and developing these beautiful remains. A mere list of them would include nearly all the Upper Silurian forms in Britain. It will be necessary, therefore, to give only the more striking forms. The asterisks denote the comparative abundance of the species.

Among the trilobites the following are conspicuous:—

Calymene Blumenbachii *****, the Dudley trilobite or Dudley locust, an universal Silurian fossil.

Homalonotus delphinocephalus, a fine species, more common in the Woolhope limestone.

Lichas Anglicus ****, and *L. Barrandii*, with three other species.

Acidaspis Brightii ***, *A. quinquespinosa* ***, *A. crenata*, the large *A. Barrandii*, ***, &c.

Staurocephalus Murchisoni, found also in Lower Silurian rocks and in Bohemia.

Cheirurus bimucronatus *, and *Sphærexochus mirus* ** (this last ranges to America).

Encrinurus punctatus ******, and *E. variolaris* ******, the strawberry-headed trilobites of Dudley, among the commonest of all the Dudley species.

Phacops Downingiæ ****, *P. Stokesii*, and *P. caudatus* **, all of them very common species.

Proetus latifrons, M'Coy, with another species, and the beautiful little *Cyphaspis megalops* ****, in which last, as well as in several other species above mentioned, the Dudley specimens show more or less clearly both sexes—the males narrower and with longer spines than the females.

Then of other classes, the *Annelida* for instance, we have *Cornulites serpularius* and *Tentaculites ornatus* in myriads. Dudley is especially rich in corals and *Crinoidea*. Of the last, multitudinous species are in

the hands of Messrs. Fletcher and Gray, and are yet unpublished. The *Cystideæ* belong to another order of Echinoderms, and of these there are no less than ten species of the genera *Apiocystites*, *Echino-encrinites*, *Ischadites* (a doubtful Cystidean), *Prunocystites*, and *Pseudocrinites*; all which are described by Prof. Forbes in the Memoirs of the Geological Survey.* Of true Crinoids we have no less than 23 forms already catalogued, but double that number are yet undescribed. Among the more conspicuous are the *Crotalocrinus rugosus*, a crinoid with net-like arms and a singular tuberculate stem, covered at its lower part with root-like processes.

Cyathocrinus, four species.

Dimerocrinus decadactylus and *D. icosidactylus*. The names imply the difference of character in the arms.

Of the genus *Eucalyptocrinus*, with its massive stomachal plates, two species occur at Dudley, *E. decorus* and *E. polydactylus*, and one at Walsall, *E. granulatus*. *Platycrinus? retiarus* is not rare.

Cheirocrinus serialis is a remarkable pendulous form. *Marsupiocrinus cælatus*, two species of *Pisocrinus* (a minute fossil), *Taxocrinus tuberculatus*, and *Icthyocrinus pyriformis*, with *Glyptocrinus expansus*, are quite common fossils; and the long necklace-like stems of *Periechocrinus moniliformis* occur on almost every slab of Dudley limestone.

The corals are still more numerous, and though there is no evidence that the Dudley limestone possessed the character of a coral reef, yet the floor of the sea must have been nearly covered with them. They are chiefly solitary forms, however, never exceeding a foot or two in diameter, and even this is rare. The more massive compound ones are *Acervularia ananas*, *Arachnophyllum typus*, *Cyathophyllum truncatum*, *Favosites alveolaris*, and *F. Gothlandica*; the chain coral, and *Heliolites interstinctus*; occasionally one or other of the five species of *Syringopora*. *Sarcinula organum*, Linn., is more commonly Lower Silurian. Of the large cup corals, *Cystiphyllum Siluriense* and *C. cylindricum*, *Cyathophyllum angustum*, *Ptychophyllum patellatum*, and *Zaphrentis lata*, are conspicuous, with *Omphyma turbinatum*, the largest and commonest of all. Three species of *Palæocyclus*, a little mushroom coral, are beautiful forms. The smaller *Millepores* and branched corals are the most numerous. *Alveolites Labechei*, *A. repens* and *A. seriatoporoides*, *Chætetes Fletcheri*, *Cœnites intertextus*, *C. juniperinus*, and *C. labrosus* are minute-celled species. *Favosites cristata* has larger tubes. Two or three species of *Heliolites*, such as *H. Grayi*, *H. petalliformis*, and *H. tubulatus*, *Labechia conferta*, *Thecia Swindernana*. The last four species are everywhere found in Wenlock limestone.

There are a good many minute coral-like forms now more correctly referred to the *Bryozoa*, some of which are encrusting and parasitic (*Diastopora* and *Discopora*), others have free cup-like or net-like fronds, *Fenestella*, *Polypora*, *Glauconome*. Some are foliaceous, like the *Eschara* of our coasts; *Ptilodictya lanceolata* and *P. scalpellum* represent these, and are very common species.

Many of the *brachiopod* shells have been quoted above from the lower limestone band. To these the following must be added, and the more abundant ones are indicated by asterisks:—

	D. Dudley;	W. Walsall.
Orthis Bouchardi	-	W. **
O. Lewisii	D.	W.
O. hybrida ****	D.	W. *****

* Vol. II., Part II.

	D. Dudley;	W. Walsall.
O. biloba ****	D. -	W. *****, very large.
O. rustica **	D. -	W. *****
O. var. *rigida* **	D.	
O. calligramma, var. *Davidsoni*	D. -	W.
var. *Walsalliensis*	-	W.
Strophomena filosa	D.	
S. antiquata, large (*S. scabrosa*, Davidson)	D. ****, these are but one species.	
Spirifer sulcatus	D. ****, a minute species.	
Sp. plicatellus	D. *******	
Sp. var. *interlineatus*	D. **	
Sp. var. *globosus*	D. ****	
Sp. trapezoidalis	D. ****	W.
Sp. crispus	D. ****	W. ***
Pentamerus galeatus	D. ****	
Rhynchonella Stricklandi	D. ******	
Rh. deflexa	-	W. *****
Rh. didyma	-	W. *
Rh. Wilsoni	D., several varieties.	
Rh. borealis	D. ****	
Rh. Lewisii	D. ****	
Retzia cuneata	D. ****	
R. Salteri	D. ****	
R.? Capewellii	D. **	W.
Discina rugata	D.	
D. Forbesii	D. *	
Crania (a radiated species)	D.	

There are but few lamelli-branchiate shells; *Orthonota cingulata*, however, is not uncommon, and

Pterinea retroflexa **	D.	
P. Danbyi, or allied species	D.	
Avicula mira, Barrande	D. ***	W. ***
Mytilus mytilimeris	D. *****	W. *****
Ctenodonta Anglica	D.	

are a few of the more ordinary forms.

Of *Pteropods* and ordinary spiral shells, *Conularia Sowerbyi* is abundant enough, and of several varieties, and probably there is another species.

Murchisonia Lloydii, *M. undata*, *M. balteata*, *M. articulata*, and at least seven other species, chiefly from the limestone.

Euomphalus alatus, *E. funatus*, *E. sculptus*, *E. discors*, *E. rugosus*, *E. carinatus*, and two or three undescribed ones.

Cyclonema carinata, and *E. corallii*; *Turbo cirrhosus?*; *Macrocheilus*; *Natica*; *Acroculia prototypa*, and *A. Haliotis*, with many species as yet unnoticed of all these genera.

Lastly, there are several *Cephalopodous* shells, though most of these are among the rarer forms.

Orthoceras annulatum and its variety, *O. fimbriatum*, is most common.

Phragmoceras pyriforme occurs at Dudley, *Lituites cornu-arietis*, and *L. tortuosus* are only occasionally met with.

There are several rarer fossils, which we can scarcely do more than notice here; among others, two species of *Chiton*; an *Ischadites*,

distinct from *I. Kœnigii; Pleurorhynchus æquicostatus;* new species of *Bellerophon; Pleurotomaria; Chemnitzia; Cyclonema;* and other spiral shells. We may hope to have several of the new species published under the auspices of the Palæontographical Society.

The limestone was evidently a deep-water formation, and very tranquilly deposited.

5. Lower Ludlow.

Of the next succeeding or Lower Ludlow formation no list has been yet published. From the neighbourhood of Parkes Hall a good many species have occurred to the persevering search of Mr. John Gray. The following are a few of these. Bivalves seem to have been the most abundant, such as—

Orthonota semisulcata, O. impressa, O. rigida, O. amygdalina; Pterinea lineatula, P. Sowerbyi; Avicula ampliata and *A. mira; Mytilus mytilimeris; Goniophora cymbæformis; Schizodus; Cardiola striata;* and many others.

Several of the *Brachiopods* which occur in the limestone are also found in the shale, and need not be repeated here.

The *Lingula Lewisii* and *Discina rugata, D. striata,* and a new species, are frequent. *Strophomena euglypha, S. depressa,* &c. *Orthis* is rare. *Spirifer interlineatus, Pentamerus galeatus* and *P. linguifer, Althyris tumida,* and *Rhynchonella Wilsoni,* are some of them.

Spiral shells are numerous, though not of many species.

Pleurotomaria undata; and a new discoid species; *Murchisonia Lloydii; Euomphalus alatus; Conularia; Cyrtolites,* large and fine specimens; *Bellerophon dilatatus, B. trilobatus,* of very large size, and at least two other species; of *Cephalopods, Orthoceras angulatum, O. bilineatum, O. annulatum, O. perelegans, Phragmoceras compressum;* the large *Lituites giganteus,* and the small and rarer species, *L. articulatus,* all occur in these prolific shales.

Encrinites and corals are but scarce; and of *Bryozoa* only *Ptilodictya lanceolata* has yet been found; *Trachyderma squamosa,* an annelide common in the Lower Ludlow rocks of other localities, is found also here. There are six or seven species of trilobites, the *Calymene* and *Encrinurus variolaris* being the chief. *Phacops caudatus* is not uncommon; and the valves of a large *Ceratiocaris* are in Mr. John Gray's collection.

6. Aymestry Limestone (Sedgley, &c.)

But few fossils have been collected from this band, which nevertheless has an historical interest in connexion with the Silurian System. The limestone of Sedgley was clearly distinguished from the underlying Wenlock bands by the late Rev. T. T. Lewis, who correctly compared it with his native Aymestry rocks. The *Pentamerus Knightii* is found in it abundantly, but it is worth notice that this most characteristic shell occurs (though rarely) in the Wenlock of this very locality, and also of Presteign. It is also found in the Lower Ludlow rocks of several districts. Its true place is, however, clearly in the Aymestry limestone. At Sedgley, at the Beacon Hill, and at the Park School, some of the other Aymestry fossils have been found, viz., *Phacops caudatus,* the common *Atrypa reticularis, Spirifer plicatellus,* variety *interlineatus,* and *Rhynchonella Stricklandi,* together with *Strophomena depressa,* a *Turbo,* and a cup coral. There must be many more if the rock were carefully searched.

From the Upper Ludlow rocks, if they exist above these, no organic remains have yet been collected.

The chief peculiarity in the Silurian strata in this district is the separation of the Wenlock limestone into two bands. The same fossils occur in both bands and in the intermediate thick band of shale.

The list above given is the first corrected catalogue, I believe, yet published of the rich fauna of the Dudley limestone. It might be greatly extended.

J. W. S.

CHAPTER VIII.

DESCRIPTION OF THE ROCKS—*continued.*

Igneous Rocks.

THERE are two varieties of igneous rock in the district; namely, Basalt and Greenstone, and another apparent variety, differing greatly from both in mere external characters. All three, however, are different parts of the same great mass of molten matter, their variety depending probably more on the conditions under which they have been placed than on any difference in the origin or mineral constitution of the rocks themselves.

The "Rowley rag" is a Basalt, a hard, heavy, black, close-grained rock, weathering brown outside, having a tendency to form spheroids that envelope with several concentric coats a solid ball in the middle, and consequently often assuming a columnar structure, which in some instances becomes nearly as regular as that of the Giant's Causeway. This is the stone of the Rowley Hills, Barrow Hill at Pensnett, Pouk Hill at Bentley, and other spots.

Of this rock an analysis has lately been made by Mr. Henry of London, for Mr. S. H. Blackwell, of Dudley, who has kindly placed it at my disposal.

Composition of Rowley Rag (specific gravity 2·907).

Silica	49·860
Alumina	12·750
Lime	8·710
Magnesia	4·395
Protox. iron	11·380
Perox. iron, with manganese	3·360
Soda	5·250
Potash	0·570
Titanic acid	1·330
Phosphoric acid	0·580
Water	2·560
	100·745

Burrowing in the Coal-measures, and here and there coming out to the present surface, is another igneous rock called "green rock" by the colliers. This is generally, if not always, the true "Greenstone" of mineralogists, composed of orthoclase and hornblende,*

* On the authority of Sir H. De la Beche.

sometimes fine-grained or compact, sometimes largely crystalline. It contains sometimes fibrous radiated masses and plates of some zeolitic minerals.

From this Greenstone proceed dykes and veins of "White rock" trap, which at first sight might be mistaken for a compact sandstone, but when closely examined bears a greater resemblance to a partly decomposed, white, compact, and somewhat earthy felstone. In some places little shining facets of feldspar may be detected in it. The colliers all unite in stating that this "white rock" proceeds from the "green rock," and though I have never myself seen the junction of the two rocks, I have no doubt of the fact. That the "white rock" is an igneous rock, as well as the "green rock," is proved by its cutting through the coal and other beds in the same way that the green rock does, and by its producing the same amount of alteration in them.

A specimen of this trap was analysed by Mr. Henry, which gave the following results:—

Silica	38·830
Alumina	13·250
Lime	3·925
Magnesia	4·180
Soda	0·971
Potash	0·422
Protox. iron	13·830
Perox. iron	4·335
Carbonic acid	9·320
Water	11·010
	100·073

This composition shows us at once that the rock cannot belong to the siliceous class of the Felstones or Trachytes, but is one of those basic compounds to which the Greenstones, Diorites, and Dolerites belong. Moreover, the presence of so large a per-centage of carbonic acid and water shows that the rock has now a different composition from that which it possessed before the period of injection, when it was in a molten condition. It is, in fact, an altered rock, altered by having had so much carbon, oxygen, and hydrogen added to it as to give it a per-centage of 20·330 of carbonic acid and water. If we deduct those materials from Mr. Henry's analysis, and reduce the remainder to per-centages, we get—

Silica		48·8
Alumina	16·7	22·1
Peroxide of iron	5·4	
Lime	4·8	29·0
Magnesia	5·2	
Soda	1·2	
Potash	0·5	
Protox. iron	17·3	
		99·9

A composition quite sufficiently near to that of a basic kind of greenstone or basalt for us to look upon it as one.*

I shall not venture to intrude into the province of the chemist so far as to speculate on the way in which these additions were given to the rock, except by observing that the rock penetrates coal, and that the three ingredients acquired, namely, carbon, hydrogen and oxygen, are the essential constituents of coal.† Neither will I attempt to decide whether the infusion of these materials into the mass of the rock took place immediately on its injection into the coal, and while it was cooling and consolidating, or whether it was the result of the slow and gradual process of purely aqueous infiltration during long subsequent periods.

Basalt.

Rowley Hills.—Of the basaltic rocks, the largest exhibition is that on the summit of the Rowley Hills. A capping of columnar basalt here rests upon the Coal-measures, over an irregular space two miles long by more than a mile in width at one part. This capping seems to be of irregular thickness, as it is largely quarried at some places on the side of the hills at least 100 feet below their summits; while on the line of the new Netherton tunnel of the Old Birmingham Canal no basalt was met with in any of the shafts, not even in the highest, which is very little below the crest of the ridge.

These shafts, however, seem to have passed through some pale green rock, slightly schistose and ashy-looking, with a crystal of feldspar here and there in it. There are also to be seen occasionally, on the slope of the hill just below the basalt, some considerable beds of trappean breccia, or brecciated ash, containing

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* M. Durocher, in his Essay on Comparative Petrology, gives the following as the mean composition of Basalt and Diorite, of which latter term we may consider Greenstone as the English synonym :—

	Diorite.	Basalt.
Silica, with trace of Titanic Acid	53·2	48·0
Alumina	16·0	13·8
Potash	1·3	1·5
Soda	2·2	3·0
Lime	6·3	10·2
Magnesia	6·0	6·5
Oxides of Iron and Manganese	14·0	13·8
Loss by ignition	1·0	3·2
	100·0	100·0

(Essay on Comparative Petrology by M. J. Durocher, translated from the Annales des Mines, vol. xi., 1857, by Rev. S. Haughton. Dublin, M'Glashan and Gill.)

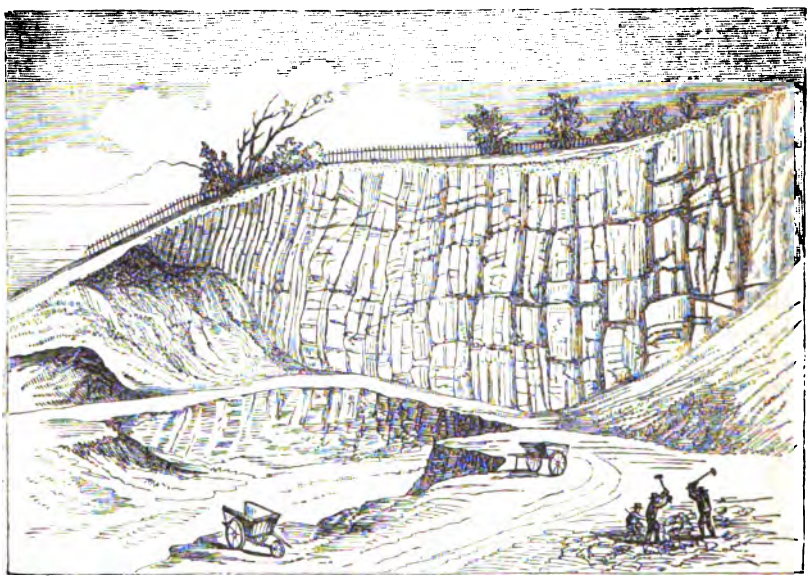
† According to Bischof, bituminous coal may be taken as essentially composed of—

Carbon	82·1
Hydrogen	5·5
Oxygen and Nitrogen	12·4
	100·0

independent of a variable admixture of earthy matter forming the ash.

rounded and angular fragments of igneous rock lying in a brown, rather ferruginous paste, that looks like the *débris* of a basaltic rock.

Fig. 12.



Coxe's Rough, Basalt Quarry.

If these beds be connected with the basalt, which seems almost certain, it shows that the basalt was an *eruptive** rock, poured out at the surface in the form of a *sheet of lava*, whether subaqueous or subaerial, immediately after the formation of the part of the Coal-measures which lie below it. These trappean breccias or conglomerates belong to and pass into the Coal-measures, and therefore the basalt of the Rowley Hills also belongs to and forms part and parcel of the Coal-measure series. That it was formed during the Coal-measure period seems also to be probable, from the fact that it has been subsequently affected by all the dislocations and other accidents that have happened to the Coal-measures.

The Netherton tunnel has lately been driven right through the base of the ridge between Oakham and Farnley Hill, running from Tividale to near the Gads Green reservoir. Eight or nine shafts were sunk from the surface along the line of this tunnel down to its level, which is that of the canal at Tividale, or 484 feet above the sea. Neither in the tunnel nor in any of the shafts

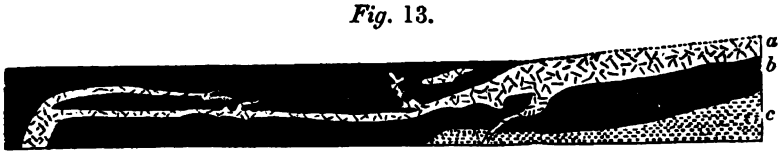
* This term of "eruptive" is sometimes applied to granitic rocks, which, however intrusive they may have been, clearly cannot have been *eruptive*, that is, can never have burst out to the surface. I would, therefore, by an eruptive rock mean only such a rock as could have been ejected out of the earth and poured over its surface, whether that surface was there covered by air or by water.

was any solid basalt met with, though one or two strings or tortuous veins of trap seem to have been cut through in the tunnel.*

The mass of the rock passed through both in the tunnel and the shaft consisted of a reddish and greenish coloured clay or shale and sandstone, sometimes the argillaceous, sometimes the arenaceous character predominating. The sandstones often contained pebbles, and thus passed into conglomerates. It was only in the upper shafts, those numbered 5, 6, and 7, that the green ashy rock mentioned above seemed to have been got, so far as I was able to judge from an examination of the spoil banks.

The Thick coal has been worked round three sides of these hills, and it appears generally to dip under and pass beneath the basalt. On the north side only, however, has it been followed under the basalt, and that for but a very slight distance; and in every instance in which this has been attempted the coal has been found to be "blacked" and to be fractured, and frequently to pass into "rock and rig." A coal is said in this district to be "blacked" when, by its near proximity to an igneous rock, it has become so altered as to lose all its brightness, and nearly, if not quite, all its inflammability. It is not exactly coke, but is dull and earthy, and on exposure to the atmosphere is very friable. It frequently in this state contains small nodular concretions of iron pyrites. I have never had the opportunity of examining a pit where the coal was thus affected, except Mr. Percy's pit, now belonging to Dr. Percy, at the Grace Mary colliery, a little east of Rye Cross Farm. Here, at a depth of about 200 yards, they came into blackened coal, penetrated by long dykes of white rock trap, and more or less intermingled and mixed up with white sandstone. This white sandstone was full of little patches and shreds of coal, and the coal was frequently entangled in the sandstone, and the two mixed up together in a very singular way. This kind of sandstone is that called by the colliers "rock and rig" In one of the gate-roads of this colliery the white trap ascending from the floor, or descending from the roof, cut both into the coal and the sandstone, in the manner shown in Fig. 13.

Fig. 13.



Scale, 20 feet to 1 inch.

a The white-rock trap.
b The coal.
c White sandstone (rock and rig).

This was drawn to scale with a measuring tape, and is a sufficiently accurate representation of the facts. A little north-west of this part of the mine a fault was met with, beyond

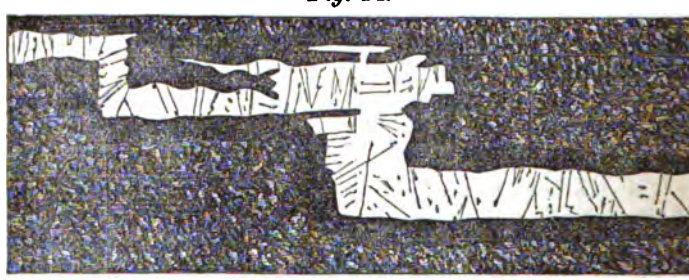
* Mr. Walker, jun., who superintended the works of this tunnel, was good enough to let me see a large section constructed from the workings, from which the above statements were taken.

which the Thick coal was found uninjured either by trap or by "rock and rig."

On a subsequent visit to these pits in 1858, I examined, with Mr. Cooksey, some gate-roads that had been driven in a southerly direction, or towards the part of the ground which is capped by basalt. The sandstone called "rock and rig" came in in larger quantity in that direction, as before described, p. 50, and the veins of white rock trap became very numerous. In one of the gate-roads a horizontal vein of trap, about a foot, or a foot and a half, in thickness, ran horizontally and regularly in the middle of the coal for 40 or 50 yards, looking precisely like a deposited bed, but then suddenly cut up across two or three beds of coal, sent off a number of irregular strings and bosses into the coal, and then shot off again horizontally near the roof for some distance, see Fig. 14. The mass of this coal was a perfectly clean, bright coal, with brilliant surfaces on the face and joints. For a distance of 6 inches to 12 inches, however, from the trap the coal was "blacked," that is to say, it was dull and friable, with an earthy look, having neither the dice-like division into lumps, nor the brilliant shining surfaces which the rest of the coal had.

Fig. 14 will give the representation of these facts from a sketch made on the spot with as much care as I could draw it, the white part representing the trap, the black border round it the altered coal, and the mottled part the coal retaining its brilliancy.

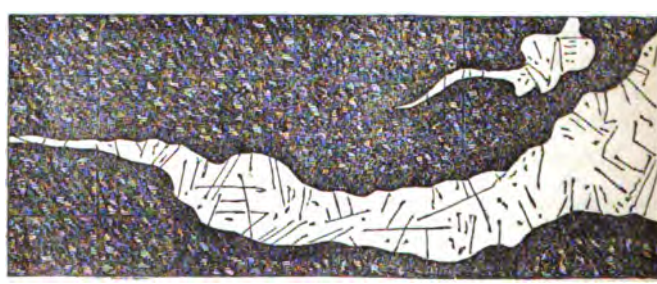
Fig. 14.



SCALE FIVE FEET TO ONE INCH.

Fig. 15 is taken from another sketch made on the same occasion, showing the termination of a considerable mass of this trap, and a little isolated boss of it in the coal.

Fig. 15.



SCALE TEN FEET TO ONE INCH.

All parts of these galleries, indeed, were riddled as it were with these trap veins running here and there in the coal, and also in the sandstone, altering the coal to a greater or less extent according to the bulk of the trap, but producing very little apparent alteration in the sandstone.

The men in this colliery call this white rock the "door-case rock," because in one of the gate-roads formerly driven in the part of the coal which is generally devoid of trap, an upright vein of it crossed the gate-road like a wall, and appeared when cut through like a white door-case in the black coal.

From the fine tortuous and branching veins which this rock forms, it seems hardly possible to suppose that at the time of its injection it was not in a fluid state, and almost perfectly liquid. The distances to which these narrow veins run seem also to make it necessary to suppose that at the time of injection it had a temperature not merely just sufficient to melt it, but a much higher one, sufficiently high to allow of the loss of a considerable quantity of heat, and yet for the matter to remain still molten in its passage to very considerable distances from the volcanic focus. Doubtless the injection was a rapid one, but still some heat must be lost in the passage of these comparatively thin sheets of molten matter over such very considerable areas.*

Now, if masses, however comparatively small, having such an intense heat as above supposed, come in contact with a substance so easily affected as coal, we should at first expect it to be almost entirely consumed, or at all events altered to a much greater extent than it appears to have been. Our ideas, however, are derived from witnessing the effects of heat at the surface, and in contact with the atmosphere. Might not these ideas lead us astray, if we reasoned from them as to what would take place at some depth in the earth, unless we made allowance for the total or nearly total absence of air, and the effect of the covering of rock, which would greatly obstruct the dissipation of the constituent gases of the substance acted on, rendering that dissipation very difficult and therefore very small?

Is it altogether impossible that the nature of the alteration was rather the extraction of a certain portion of the hydrogen and oxygen of the coal, together with some of its carbon, and the combination of those substances with the oxides previously existing in the igneous matter, rather than the expulsion of those gases into the rocks above or below the coal? In this way the greatest amount of metamorphosis would be produced in the substance of the igneous rock, some part of the matter of the coal being actually absorbed into it and used up by it, and its constituents combined with its own as it passed along. The blackened margin of the coal

* M. Delesse, in his "Etudes de Metamorphism," supposes in these cases that the intrusive rock had not such an intense temperature, but that it was mixed with water into a state resembling mortar. It does not appear to me, however, possible for a mere paste to be injected into fine crevices to such great distances as we find in the above and other cases.

about the igneous rock would then represent that small part of the coal that was altered by having some of its gaseous constituents sucked out of it, as it were, leaving a coating of nearly pure carbon as a non-conductor to protect the remainder of the coal.

The only explanation of the occurrence of the sandstone called "rock and rig" I can offer is, that it is part of a "rock fault," a mass of sandstone contemporaneous with the coal, as described before, p. 48. Whether its connexion with the trap be accidental or otherwise it is difficult to determine. I am inclined to think, from the frequency of the occurrence of these "rock faults" in the coal in the neighbourhood of the Rowley Hills, and their absence, so far as I know, at any great distance from them, and from "rock and rig" being found around Barrow Hill, that their connexion with the trap is not accidental. It seems possible that the volcanic focus from which was subsequently protruded the molten basalt, gave some indication of its existence, even at an early period in the formation of the Coal-measures; and that from some troubled action fracturing the rocks, and either generating springs that brought up sand from below, or causing currents, perhaps of considerable local intensity, in the water above and around, which might sweep in sand from a distance, sandy beds might be deposited that locally interfered with the production of the Thick coal.

We have as yet no means of ascertaining the focus or centre of eruption from which the basalt of the Rowley Hills was poured out, and from which the sheets and veins of greenstone and "white rock" trap proceeded. No central pipe or funnel has yet been met with, but, except in the Netherton tunnel, no large exploration has yet been continued beneath the basalt.

The deterioration of the Thick coal by the quantity of sandstone that seems to come into it as the hills are approached is one reason for its not having been followed as yet beneath them. The fear that the coal which may exist is partly destroyed by trap rock is probably another reason.

It may still happen that at some point round the Rowley Hills *good unaltered* coal may be found for some distance beneath the basalt, but at present all the known evidence is the other way.

Barrow Hill.—Barrow Hill, two miles west of Dudley, is another mass of basalt in every respect similar to that of Rowley, except in extent and in its position with respect to the Thick coal. The Rowley columnar basalt seems to lie at a height of about 600 feet above the Thick coal, that of Barrow Hill is apparently at a much less height. If they are each contemporaneous with the beds in which they lie, it follows that the Barrow Hill trap is older than that of the Rowley Hills. Immediately east of the hill, it appears, from the marks of old workings, that a piece of Thick coal cropped to the surface, and was worked in open work along it. This piece lay in an angle between the Corbyn's Hall fault and another, which is supposed to run south of Barrow Hill. In the workings to the west of Barrow Hill the coals are found to be "blacked" as they approach it, and beds of "green rock" (horizontal dykes) are

found between the measures to the east for a distance of about two miles.

Pouk Hill.—Pouk Hill, near Walsall, is another mass of columnar basalt of less size than Barrow Hill, but equally, or still more, interesting.

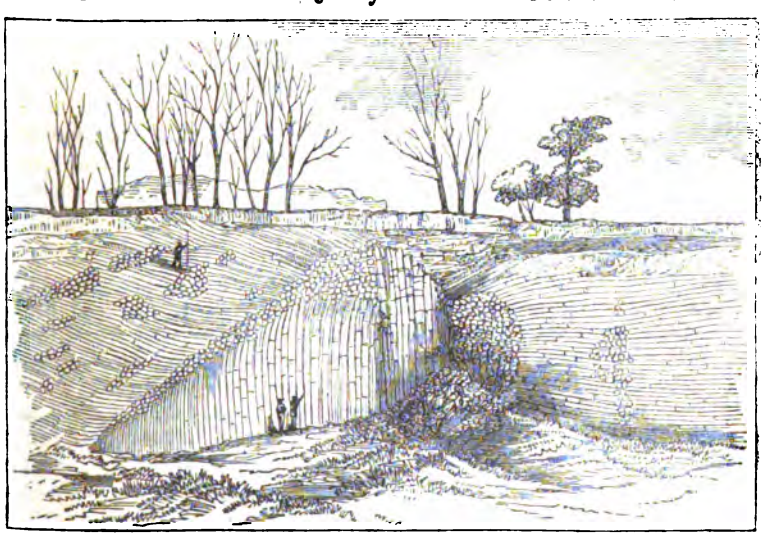
It lies altogether below the Thick coal and between the Fire-clay and the Bottom coal.

It formed a small slightly prominent mound of about 100 yards across, but this is now nearly all quarried away. The quarry, however, in 1858, exposed the structure of the rock in an admirable manner, and showed that structure to be very interesting and peculiar.

In the centre of the quarry the columns, which were often very regular, were vertical over a space of some 20 yards in diameter. In the middle part of this space the columns continued vertical till they reached the surface, but on the western side the tops of these vertical columns curved in for the space of a yard or so, and were at last quite sharply bent inwards so as to have the transverse section of the columns facing towards the centre of the quarry. The line along which this curvature took place sloped obliquely down from the top of the quarry to the floor at an angle of about 35°, and above that line all the columns lay in a position more nearly approaching the horizontal than the vertical. The ends of the columns slightly curved up along the line of junction so as to become nearly parallel to the bent tops of the vertical columns, and rose in the other direction into angle of about 20°, so as to suggest the idea of a radiation from this inclined line of junction.

Fig. 16.

Sketch of Pouk Hill Quarry as it was in October 1858.



On the eastern side of the quarry the columns likewise lay in slightly bent, but nearly horizontal lines, though here the change

from vertical to horizontal was in one part more abrupt and in another seemed to have been more irregular. The state of the working of the quarry, too, obscured the relation of the columns on that side. A number of uncompressed spheroids of basalt appeared in one part along the line of junction of the vertical and horizontal columns.

On the south-east side of the quarry the black shales of the Coal-measures might be seen reposing on the basalt, which just below them consisted chiefly of uncompressed balls of basalt, bedded in a mass of decomposed basalt or basaltic "wacké" or clay. A small cutting for a tramway led from the quarry south to the canal, and following down this the Coal-measure shales containing ironstone were seen lying nearly horizontal. At one part these shales were traversed by a small dyke of white rock trap cutting across them at an angle of about 60° with the horizon, and rather more than a foot in width. Farther down this cutting, in consequence of a slight rise in the measures, the basaltic clay earth containing balls of basalt again made its appearance for a few yards, and then finally sank out of sight towards the south.

The columns of Pouk Hill, doubtless, assumed the radiating form above described in obedience to the rule they are known generally to follow, that, namely, of always striking from the cooling surfaces of any mass towards the interior. Thus, in a horizontal sheet the columns are vertical, in a vertical dyke the columns are horizontal, and in a spheroidal mass the columns seem to radiate from the centre, or in other words strike from all sides towards it.

Netherton.—A mass of basaltic trap is very well seen in the canal cutting south of Netherton church, where it is exposed by the rise of the beds below the Thick coal, and is seen to send wedge-like masses into the Coal-measure sandstones.

Greenstone.

Sheet-like masses of "green rock" (the local name for the greenstone) seem to spread almost uninterruptedly in the lower Coal-measures from the base of the Rowley Hills and Barrow Hill, through the centre of the district up to Wolverhampton, Bilston, and Bentley.

At Barrow Hill Coppice pits 64 feet of "green rock" penetrated the Gubbin-stone measures just beneath the Thick-coal. At the Birds Leasowe colliery, near Tansey Green, the Thick-coal was found to be "mingled with rock and rig;" and, below the Gubbin measures, "green rock" was found, into which they sunk 38 feet. Between Tansey Green and Shut End furnace the "green rock" is only 36 feet thick, and comes in in the place of the Heathen coal, the Thick coal itself being blacked. To the east of Barrow Hill a sheet of "green rock," which at first is more than 60 feet thick, but afterwards thins to about 30 feet, stretches for at least two miles in one direction. Its usual place is between the Heathen coal and the Whitestone measures, but between Cooper's Bank and the Fiery Holes the "green rock" cuts down under the Whitestone measures. This "green rock" crops regularly out like

a bed on the rising ground west of Russell's Hall, and intrusive bosses of it rise to the surface at a spot on the western outskirts of the town of Dudley, at the Fiery Holes, at the east side of Cooper's Bank, and in the brook to the west of it.

At one of Lord Ward's pits at Tividale (about a quarter of a mile north by west of Coxes Rough) they found, at a depth of 500 feet, the following beds :—

	FT.
1. Coal mingled with rock, representing Thick coal	24
2. White rock, *sandstone*	33
3. Strong rock	9
4. Binds	6
5. Gubbin measures	2
6. Coal mingled with rock (represents Heathen coal)	4
7. Green rock, sank into for	27

The usual distance between the Thick coal and the Heathen coal is only 12 or 14 feet, instead of 54, as here ; Nos. 2 and 3 being quite unusual measures.

At Dudley Port, in Mr. Bagnal's limestone pits, they passed through 15 feet of "green rock" in the lowest sandstone of the Coal-measures, just before entering the Silurian shale.

At Tipton Moat colliery and at Tipton there were 34 feet of "green rock" at a distance of 36 feet below the Bottom coal. At Deepfields they got 20 feet of "green rock" at a depth of 39 feet below the Bottom coal. At Highfields they found the "green rock" at a depth of 66 feet below the same coal, and sank into it for 15 feet only. At Bradley, in Mr. Addenhook's colliery, they found the "green rock" 55 ft. 6 in. thick at a depth below the Bottom coal of 24 ft. 6 in.

Near Bilston, in a pit in a field called Crabtree piece, Messrs. W. and J. W. Sparrow found 15 feet of "green rock" 22 feet below the Bottom coal ; and at the Wallbutts colliery the "green rock" was struck 27 feet below the Bottom coal, and sank into for 10 feet.

No "green rock" has been seen cropping to the surface on the rise of the lower measures on the north-east flank of the Dudley and Sedgley ridge ; nor, so far as I am aware, has any been met with east of Darlaston or Wednesbury, or about West Bromwich, either at the surface or under ground. A considerable boss of it is seen, however, in the canal bank between Moxley and the Broadwater furnaces, which must either belong to another mass or must cut up through the Thick coal and the beds above it to reach the surface. It may also have been met with in other situations in the workings of which the record is now lost.

In the district between Wolverhampton and Walsall "green rock" is frequently met with in sheets in the lower measures, varying in thickness from 15 feet to 80 and 90 feet. In the southern part of this tract it lies *below* the Bottom coal, but between Wolverhampton and Willenhall it cuts up through that coal) and to the north of that is always found *above* the Bottom coal, between it and the Fire-clay coal. A boss of it rises to the surface, cutting up through the New mine coal at the Heath colliery north-east of Wolverhampton, and a little north of that a large mass of it rises broadly out and forms the surface of the ground all around Wednesfield, as delineated in the map. In the Bentley district the basalt of Pouk Hill seams merely to be an irregular swelling of the bed of "green rock" that crops out a little further east along the bank of the canal. This bed is found in the underground workings for about half a mile to the westward of Pouk Hill,

and for the same distance to the northward, varying in thickness from 20 feet to 40 feet, lying always just above the Bottom coal, which is often greatly injured by it. It does not extend as far east as the Birch Hills,* nor far north towards Bloxwich, nor beyond Clark's-lane to the westward, neither was any found in Messrs. Bates's pits at the Trentham colliery between Mumber-lane and Wednesfield.

Near Wolverhampton none has been found in the Rough Hills, Cockshutts, or Parkfields collieries. At the Chillington colliery it is found, however, sometimes above, sometimes below the Bottom coal, and varying from 15 feet to 30 feet in thickness.

I was assured by Evan Lloyd, the ground-bailiff of the Chillington colliery, that there were two distinct beds of "green rock" there, as in the two following sections:—

Western part of the Chillington Colliery.

	FT.
1. Black and white ironstone	3
2. Bottom coal	12
3. Clunch	24
4. Gubbin and balls ironstone	8
5. Slums	3
6. Green rock, about	35
7. Hard rock	12

Eastern part of the Chillington Colliery.

	FT.
1. Black and white ironstone	3
2. Green rock, about	15
3. Bottom coal	12
4. Clunch	24
5. Gubbin and balls ironstone	8
6. Slums	3
7. Hard rock	12

Notwithstanding these facts the Gubbin and balls ironstone was worked continuously over the whole colliery without meeting any green rock. In this locality, therefore, there could have been no cutting up of the green rock through the measures, though it is by no means sure that these two sheets may not have a connexion elsewhere.

I was assured also by almost every one engaged in the works of this neighbourhood that, notwithstanding the variations in thickness of the "green rock," there was no change in the total thickness of the measures; that, for instance, the thickness between the New mine coal and the Blue flats ironstone remained the same, whatever might be the variation in the thickness of the "green rock." In other words, it was affirmed almost universally that the "green rock" not only intruded between the measures, but *obliterated* a mass of beds equal to its own thickness. This assertion was so confidently made by almost every *practical man* in the neighbourhood, that, however incomprehensible, I should have received it as true, had not an analysis of the materials received from them enabled me to disprove it. It is no doubt founded in fact; the greater the thickness of the intruded trap rock, the more intense, probably, would be the squeeze, and the consequent contraction suffered by the adjacent beds. Beds of coal, too, might certainly be nearly or altogether annihilated by the intrusion of molten rock, but we cannot conceive sandstone or clunch being thus destroyed. The truth is, that the original thickness of the measures was itself very variable, and it probably happened that, in one or two of the places where the facts were first observed, a partial thickening or thinning of the trap rock compensated for the reverse in the original beds. It may also have happened that the very fact of there being a local thinning of some of the upper measures gave occasion for a corresponding thickening of the intruded trap rock. That, however, the assertion before

* Beyond the Birch Hills furnaces, however, near Birch Hills Hall, trap is again found in the Coal-measures, about or above the place of the Bottom coal.

mentioned is really not borne out by the facts as to all places, may be shown by the following deductions from the pit sections furnished me in the district.

In six shafts in the Stow Heath colliery, partly in the occupation of Messrs. Sparrow, partly of Messrs. Ward, we find the following values for the thickness of the "green rock," and for the thickness of the whole measures, including the "green rock," from the top of the New mine coal to the top of the Blue flats ironstone :—

Pit.	Green rock.	Total beds from New mine coal to Blue flats.
	FT.	FT.
1.	30	164
2.	33	157
3.	51	205
4.	55	177
5.	66	204
6.	66	214

which shows that the total thickness does increase with the increase of the thickness of "green rock," although not regularly or in strict proportion, owing to the original irregularity in the thickness of the other measures.

In three pits at the Portobello colliery, just where the "hole" of "Moseley Hole," is engraved in the map, all three pits being within a distance of 264 yards, we get the following thicknesses :—

Pit.	Green rock.	Total from New mine coal to Blue flats.
1.	59	168
2.	56	104
3.	84	190

In which we find the increase in the total thickness to be very nearly in direct proportion to that of the green rock.*

In an open work in the New mine coal, some years ago, on Wednesfield Heath, a dyke of the white feldspathic-looking trap was seen cutting up into the coal from below, and ending in some black shale. In some quarries north of Willenhall the same rock may still be seen in veins cutting through the Coal-measures.

In the northern portion of the coal-field, north of Wednesfield, and Walsall, no trap rock is known to show itself at the surface of the ground, with the exception of a little spot of hard dark hornblendic trap at the Essington wood brick-kiln, only to be seen in a small quarry partially concealed by underwood, and surrounded by the red clays of the upper Coal-measures.

Much "green rock" was found in some old sinkings between Pool Hayes and the New Invention, obliging the works to be abandoned. I was informed that in some sinkings made by Colonel Vernon two or three miles north of Bloxwich on Essington Wood, the measures were found to be disturbed and altered by "white rock trap," to such an extent as to oblige them to abandon the undertaking. Large intrusive

* I have insisted a little more strongly on this point than its real importance deserves, because it is a good illustration of the error into which purely practical men are so apt to fall, that, namely, of over-hasty generalisation from insufficient data. The charge of "theorising," as it is called, is so often brought as a criminal charge against scientific men, that it is but fair to show those instances in which theory necessarily leads to truth, and therefore to safety, in order to counterbalance those in which it may occasionally have led to danger or expense.

masses of this white trap also are found in the pits near Birch Hills Hall, north of Walsall. At Union colliery, north of that, the Bottom coal is cut entirely out by "green rock;" and at Goscott, still farther north, there are six yards of "green rock" resting directly on the Bottom coal. White rock trap just shows itself in the cutting of the Cannock railway south of the bridge in the lane leading from Landywood to the turnpike road. In the rest of the field I have found no trace of the rock having been met with, and it certainly has not been seen in any of the Brereton workings at its northern apex.

Time and Mode of Formation of the Trap Rocks.—There is nothing in the mineralogical constitution of these igneous rocks that will give us any assistance in determining the geological period during which they were formed. I am not aware that the basalts of the Rowley Hills differ in any essential particular from those of the county Antrim (the Giant's Causeway, &c.), from those poured forth by existing volcanoes, or from basalt of any other period. The greenstone does not appear to differ essentially from the rock so called, which was formed during any period, from the Lower Silurian down to the most recent.

There appears, however, to be this difference in the circumstances under which basalt and greenstone were at any time formed: that while basalt is found in the lower part of the lava streams of existing and extinct volcanoes, and is therefore capable of being produced by the cooling of a molten mass on the surface of the earth, greenstone is not known to have been ever found to be so circumstanced, but always in such situations as either prove it to be an intrusive and comparatively deep-seated, or, at all events, not a superficially formed rock, or at least render it probable or possible that it was so formed.

Whether the difference between basalt and greenstone can be accounted for solely by the difference of the circumstances under which they cooled and consolidated from a molten mass into a solid rock, is a question I do not pretend to decide. My own belief is, that those circumstances exercised a preponderating influence on the distinction between the two rocks, and this belief is supported rather than opposed by the facts to be observed in the South Staffordshire coal-field.

If the ashy-looking beds associated with the Rowley basalt be really of the nature of "ash" or "tuff,"* then it follows, as a consequence, that the Rowley basalt is part of an actual lava stream poured out at the surface, either into the air or into the water. The time of this ejection was apparently after the formation of 600 or 700 feet of Coal-measures over the Thick coal, probably after the deposition of the red coal-measure clays, and about the commencement of that of the Halesowen sandstone group.

* By "ash" or "tuff" I would understand the débris of an igneous rock, either produced by the action of water at the time of its being poured out, or immediately after, or by the action of steam or other gases rushing from the volcanic focus and ejecting the débris into the water, or into the air so that it ultimately fell into the water.

The intrusive sheets, dykes, and veins of "green rock" and "white rock" trap which burrow in the lower measures about the Thick coal and beneath it on the northern side of the Rowley Hills, and seem to spread through the centre of the district as far north as Wednesfield and Bentley, and thereabouts, may have commenced their intrusions some time before the outpouring of the Rowley basalt, which, giving a sensible and large relief to the struggles of the volcanic matter below, may have terminated the igneous action.

There may also be seen, in the neighbourhood of Barrow Hill, rocks having the character of ash or trappean débris, and it may be that that outburst of basalt likewise reached the surface, though from its position above the Thick coal it would appear in that case to have taken place at a rather earlier period than that of Rowley.

About Pouk Hill, there is no appearance of ash, and it seems to be so intimately associated with the horizontal sheet of greenstone, a short distance below, that I am more inclined to look upon that as a boss proceeding from it, not to the surface, but only *towards* the surface, and consolidating in an isolated mass at no great distance perhaps, below the surface of the rocks that existed at the period of its formation.

In all cases the isolated masses that are found in the higher parts of the Coal-measures are, I believe, basalt, while the wide spread horizontal sheets of igneous rock that spread over such large areas below, and occasionally make their appearance at the surface where the lower measures crop out, as about Wednesfield and to the east of Pouk Hill, are greenstone.

It is not by any means intended to insist too strongly on the superficial formation of the Rowley or Barrow Hill basalt, since except the occurrence of the ashy-looking beds, and the basalt being always above the greenstone, there is no conclusive evidence to show that these basaltic masses were not also intrusive sheets of igneous matter injected in between the beds of the Coal-measures.

If the basalts were outpoured lava streams, it of course follows that all the igneous rocks, taken as a whole, were contemporaneous with the Coal-measures, taken as a whole.

Even on the supposition of the igneous rocks being all intrusive, and therefore formed subsequently to the formation of the beds between which they now lie, I still think that we cannot assign a much later age to them, and that we shall be compelled to consider them as older than the Permian rocks.

The first argument in favour of this conclusion is a negative one, namely, that in this district no igneous rocks of any kind are found in any formation newer than the Coal-measures.

So long as the red clays of Essington Wood were considered to be of Permian age, this argument failed us as regards that formation, since there is a little boss of a peculiar kind of greenstone to be seen in a small quarry just west of the brickpits of that place. Now that these red clays are proved to be Coal-

measures, however, this occurrence of igneous rock in them becomes no exception to the general statement given above.

The second argument is of a more positive character, and is this, that *at whatever period these igneous rocks were produced, they were all existent before the production of the faults and dislocations that have traversed the Coal-measures, and before any great denudation had been effected on the country.*

The northern end of the Rowley Hill basalt is distinctly cut off by the extension of the northern of the pair of Dudley Port Trough faults and the southern of those faults seem also to have affected it.

The sheets of greenstone that spread from below the Rowley Hills, through the centre of the district, up to Wednesfield and Bentley, always run pretty nearly in the same beds, at whatever depth those beds may be found, and however they may be broken by faults. This shows that the "green rock" is itself cut through by the faults and thrown up or down by them, as the case may be, exactly as the Coal-measures are affected by them.

The same may be said in general of the sheets of "green rock" proceeding at a higher level from Barrow Hill. In each case the "green rock" crops out to the surface, along with the beds in which it lies; although as its thickness is very irregular, and as it shifts its place now and then in the beds, cutting up or down within certain narrow limits, above or below a particular set of beds, that outcrop has a corresponding irregularity and want of continuity.

This proves the igneous rocks to have been equally and similarly affected with the Coal-measures by the two great actions of "dislocation" and "denudation."

It seems quite impossible to suppose that if the faults existed before the "green rock" was injected into the measures, that it would not have taken advantage of those fissures to have made its way to the surface along them, rather than have forced itself in among and lifted up and floated a thickness of several hundred feet of beds over an area of several square miles. But since it is known for a fact that it is itself dislocated by these faults, as shown in the Horizontal (Longitudinal) Sections (Sheets 23, 24, and 25), that fact is conclusive in favour of the rock having been cooled and consolidated before those faults were formed.

My friend, Mr. S. H. Blackwell, indeed, informs me, that in the district west of Russell's Hall, south of Lower Gornal, where there are a number of step faults close together, the green rock there was found to go up into those faults. It certainly did not go up very far along them, since I believe it did not injure or intrude into the Thick coal, which there lies at no great distance above the "green rock." It may have sent veins up into the superincumbent measures along certain lines of slight resistance, which afterwards were converted into faults; or it is possible perhaps, that small dislocations were then caused before the time when the larger and more general dislocation of the coal-field was

produced. Or, lastly, with all respect to my friend Mr. Blackwell's acuteness of observation, (which no one will be more ready to acknowledge than I, who have so often profited by it,) he may have been led away by appearances which in the imperfect light of underground workings might have deceived any one. It seems to me quite possible that portions of the consolidated basalt may have been squeezed for some distance up into the fissures, and still more likely that some of the more decomposed parts (the clay or wacke, which often forms the covering of the hard rock) may have been so squeezed, at least as far as it was possible to follow it in underground explorations.

Whatever may be the exact state of the case with regard to this particular instance, the larger and more general fact remains undoubted, that there is no relation whatever either of cause or effect between the igneous rocks of the coal-field and the principal dislocations that have affected it; and that the igneous rocks all existed in and among the Coal-measures very much in their present condition before any of the great dislocations were commenced.

CHAPTER IX.

Original Relation of the Formations to each other as regards their Conformability or Unconformability.

I shall assume the conformability among themselves of the several members of the Silurian formation in South Staffordshire. This is rendered probable by their conformability in the neighbouring district of Shropshire, and there is no evidence against it in Staffordshire. Starting with that assumption, we must necessarily conclude that before the Coal-measures were deposited the Silurian beds had been slightly tilted at one end, namely, on the eastern side, and made to dip towards the west, and that their surface had suffered considerable denudation. The uppermost member of the Silurian formation, the Ludlow group, is only found on the western side of the main part of the coal-field. If we draw a nearly north and south line, starting from Ettingshall Park farm, running between Hurst Hill and Sedgley Beacon, and continue it down through Cradley to the south, we find that to the west of that line, wherever the Silurian rocks rise to the surface, namely, at Sedgley, at Turner's Hill, and the Lye Waste, they consist of the Ludlow or upper division; while all to the east of that line, wherever the Silurian rocks rise to the surface, or have been reached by shafts through the Coal-measures, they consist of the Dudley and Wenlock division of the upper Silurian series. The farther we go east, moreover, from this line, the more nearly do the Dudley limestones rise into proximity to the Coal-measures and to the surface, until at Walsall they crop broadly out, and the shales below them still rising gently to the

east, there comes out at Hay Head, near Barr, a lower limestone than has been seen in any other portion of the district.

A little to the east of that Barr limestone or of the beds which represent it, the May Hill or Llandovery sandstone, which lies next below it, makes its appearance, and would be much more largely exhibited if it were not immediately cut off by the boundary fault a little to the east of Shustoke Lodge, while near Hay Head it is concealed by a thin skirt of Coal-measures lying unconformably upon it, before both are thrown down by the boundary fault.

South of the true coal-field lies the Silurian district of the Lickey, where these same sandstones rise up from beneath the shales containing the representative of the Barr limestone. These also were elevated and denuded before the Coal-measure period, as we find thin Coal-measures resting directly upon them. It appears then that previous to the deposition of the Coal-measures there was here a broad and generally level plain of Silurian rocks (whether above or under water), the beds of which had a slight dip to the west, and cropped out successively towards the east, at the surface of the plain. The boundary of the Ludlow formation must have run somewhere along the line before mentioned, that of the Wenlock nearly along the line of the eastern boundary of the coal-field, while the Llandovery rocks spread some distance farther to the east. If any of the outcrops formed escarpments, they must have been low and gently sloping.

That this gradual rise to the east was continued yet further in that direction beyond the bounds of our district, is rendered probable by the fact of rocks still older than the Upper Silurian (perhaps older than any Silurian) appearing in the Warwickshire and Leicestershire coal-fields, with the Coal-measures resting directly upon them. It is, indeed, highly probable that all this tract of country, together with much of the adjacent district from Montgomeryshire to Leicestershire, became dry land after the close of the Silurian period, rising, perhaps, very slowly, and undergoing a very gradual and long-continued process of degradation as it passed through the destructive plane of the sea level; and that it remained above the waters during great part of the period marked by the formation of the Old red sandstone and Carboniferous limestone, and that accordingly those two rocks were never deposited upon it.

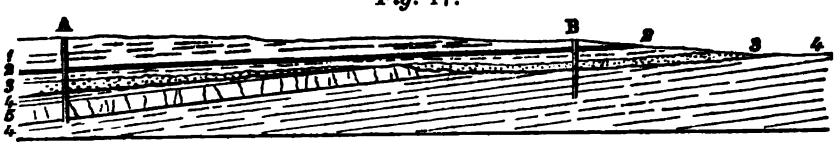
However that may be, we find that when the Coal-measures of South Staffordshire came to be formed, their earliest beds were deposited on a rather rough and cliffy (see p. 80, and Fig. 11), but generally horizontal surface, and that the dip of the Silurians, though still markedly to the west, was so slight that their beds could not at any one place have been seen sensibly to differ in inclination from the horizontal or nearly horizontal beds of the Coal-measures. We have already, in examining the base of the Coal-measures, seen the way in which at particular spots the lower beds of that formation filled up hollows in the Silurian rocks and obliterated their little pre-existing cliffs, and thus formed

a smooth floor for the deposition of the chief mass of the Coal-measure beds. (See p. 80.)

The Coal-measures, then, are distinctly unconformable to the Silurian rocks, but never so much so as that their respective angles of inclination are strikingly different at any one locality.

The practical importance of these apparently quite theoretical discussions will admit of a very apt illustration in this district. If the reader will look in the map of the district, at Walsall and its neighbourhood, he will see the Silurian limestones peeping out from under the Coal-measures here and there, and again becoming concealed by them, the Coal-measure boundary not at all strictly following the line of the limestones. Let us suppose the Coal-measure boundary to represent the outcrop of the Blue flats ironstone, which it really does very nearly, and let a sinking be made, say at the Butts, near Rushall, in which sinking, after passing through the Blue flats, the limestone was found at a certain distance, say 30 yards, below it; a person not understanding the fact of the unconformability of the two formations, might, after getting the Blue flats further east near Caudy-fields, sink down again for the limestone, and feel absolutely certain of reaching it at some depth not varying greatly from 30 yards. Instead of finding it, the pit would be sunk beyond the outcrop of the limestone altogether, as in the following diagram.

Fig. 17.



A. The first shaft.
1. Coal-measures.
2 Blue flats.
3. Lowest Coal-measures.
B. The second ditto.
4. Silurian shale.
5. Silurian limestone.

Now this very case absolutely occurred, although not exactly in the method above stated, and was described to me by Mr. Roberts, the mine agent at that very locality. It had always been a rather puzzling and incomprehensible occurrence to him, till I explained the way in which it had taken place.*

Having established the fact of the general unconformability between the Coal-measures and Silurian rocks, let us now examine the relations between the Coal-measures and the rocks above them, namely, the Permian and the New red sandstone.

1. As to the Permian.—We have already seen that in the southern part of the district we had nearly or quite a thousand feet of Coal-measures above the Thick coal, without including any Permian, or any other rock than the true Coal-measures. Now, in the sinkings at West Bromwich that took place a few years ago, several shafts passed down through a considerable thickness of Permian sandstone, and through a part of the Coal-measures

* This is one of the numerous minor difficulties in the way of intelligent practical men that I heard of while surveying this coal-field, that would have been no difficulties, had the knowledge of a little "practical geology" been attainable by them at an early period of life.

into the Thick coal. So far, however, from there being a thousand feet of Coal-measures between the bottom of the Permian and the Thick coal, there are not more than 520 feet at the Lewisham pit, 350 feet at the Lyng colliery, 330 feet at Messrs. Davis's pits at Spon-lane, and only 30 feet or 40 feet at the Heath pits of Lord Dartmouth. We have in these facts a clear case of decided unconformability between the Permian beds and the Coal-measures. We see that after the Coal-measures had been deposited they had suffered largely and very irregularly from denudation, several hundred feet of strata having been removed at one place which were left untouched at another, before the Permian beds were begun to be deposited on them. The belief of this denudation having taken place is confirmed by the appearance of angular and rounded fragments of Coal-measure rocks and pebbles of coal being found in the bottom beds of the Permian rocks at Quarry Hill near Halesowen, and at the Heath pits, West Bromwich (see Vertical Sections, Sheet 17, No. 17). We can hardly suppose this denudation to have taken place without a previous elevation and disturbance of the beds, although, as in the other case of the Silurian rocks, this elevation may have been so steady and equable that it did not cause the Coal-measures very sensibly to incline from a horizontal position.*

It is perhaps rash to generalise from the very scanty data we possess as to the precise relations between the Permian and Coal-measures. On so important a point, however, it is, I believe, a duty to state every opinion that may be fairly arrived at. I will therefore state, as my belief, that not only near West Bromwich, but *generally* in South Staffordshire and *the adjoining counties*, the Coal-measures suffered very greatly from denudation before the deposition of the Permian, and that the red sandstones of that formation were largely deposited in hollows and excavations worn in the Coal-measures by this denudation; and, moreover, that this excavation and denudation had in places proceeded to the length of being continued right through the Coal-measures down to the rocks below.

It may be useful, in order to arrive at a right understanding of this subject, if we discuss in detail the operations that were carried on at the celebrated Heath pits of Lord Dartmouth at West Bromwich. For this purpose we have the data given in Sir R. Murchison's Silurian System, and others partly collected by myself, but principally received from Mr. H. Johnson, Mining Surveyor, of Dudley. In the section published as No. 17, Sheet 17, of the Vertical sections, the actual shaft is drawn to scale, with the measures passed through, as given in the Silurian System, p. 476. On the left or west side of the shaft the section is copied from one lent by Mr. Johnson, which he compiled from the accounts of the men engaged in the sinking of the shaft, and corrected from his own measurements; and on the east side of the

* A dip of even 3° is often hardly perceptible either to the eye or to the clinometer, although it produces very large results if continued over a wide space. A bed dipping at 3° for the space of 3 miles will be 839 feet lower on the "deep" than it is on the "rise" side.

shaft are delineated to scale the headings or gateways that were driven in that direction, with the jackey pits and borings that were put up and down, together with a small ground plan both of the surface and the underground operations.

The following is a succinct account of these operations. In sinking the shaft they went down for 800 feet, through red standstones and other rocks certainly belonging to the Permian series. Below these, or at 804 feet from the surface of the ground, they entered the Coal-measures, and the following beds were passed through :—

		FT.	IN.
1.	Grey clunch, with streak of coal -	2	0
2.	Ditto, with batt at the bottom -	4	6
3.	Grey clunch - - -	18	6
4.	Grey fire-clay and ironstone - -	3	9
5.	Light greenish grey and red rock, containing a thin streak of coal - -	21	0
6.	Dark grey clunch and batt - -	4	6
7.	Dark-coloured fire-clay - -	8	6
8.	Coal - - - - -	0	6
9.	Grey fire-clay - - - -	2	0
10.	Coal - - - -	2	6
11.	Grey fire-clay rock - - -	6	0
12.	Coal - - - - -	9	0
13.	Batt, gubbinstone, and table batt -	2	0
14.	Grey clunch and lambstone - -	11	0
15.	Coal, afterwards traced to Sulphur ? coal	2	0
16.	White ironstone ground - -	4	0
17.	Grey fire-clay and ironstone - -	4	0
18.	Dark grey clunch and flattened concretions of ironstone - - -	14	0

No. 12, the nine-foot coal, was recognised as the bottom part (Slipper, and Sawyer, and Benches) of the Thick coal, with the Gubbinstone and Table batt thinner than usual below it. No. 15 was said to have been afterwards traced into the Sulphur coal ; but if No. 16 was rightly identified as the "White ironstone ground," this could not have been the case, as the Sulphur coal lies below the White (or New Mine) ironstone, and therefore No. 15 must have been the Heathen coal.

In examining the engraved Vertical Section, Sheet 17, No. 17, the reader must bear in mind, that while the measurements and position of the beds, as found in the pits, headings, and actual explorations are certainly accurate, the lines connecting these parts may not be exact representations of nature. They are probably only approximations to the truth, especially the shapes and positions of the coals to the west of the shaft, and the line marked "general boundary of the rock fault" on the east.

A "heading" was then driven in No. 12 for about 50 yards to the south-south-east, when the coal was found to thin out by the descent of its roof and come to nothing. A second heading was then driven 140 yards to the east-south-east, through Coal-measures lying in a very irregular condition, and at the end of that heading a bore hole was driven upwards, which at 12 or 15 feet above the heading passed through a three-foot coal, and was continued through dark clunch, for a total height of 100 feet, up into the "red rock." A third heading was then driven nearly parallel to this for about 35 yards, and at the end

of it a "jackey pit"* was sunk for 81 feet, through fireclay and sandstone, and from the bottom of that a boring was made for 180 feet lower. This bore hole was said to pass almost entirely through "Bavin measures," (by which Silurian shale is meant,) and these were said to be "very strong towards the bottom, in fact, defied all attempts to bore lower."† A fourth heading was then driven to the east by north for about 170 yards. This, after passing through the nine-foot coal before described, "went level away for 70 or 80 yards through an intermixture of black ground and binds. We then faced the Bavin measures, which seemed to pitch a little for 20 yards, and then ran level away to the back of the head." At the back of the head a two-inch bore hole was put up for 128 feet, which passed through about 17 feet of Bavin, and then dark clod for the remainder of the distance, above which they struck the "red rock," when so much water followed that the hole was obliged to be plugged up immediately. A two-inch bore hole was also put down here for 180 feet, passing through "Bavin" measures the whole way, and finally ended in what we considered to be (as in the case of the hole in the jackey pit) the limestone. Shells were found in great abundance in the Bavin measures of this head."‡ After making these fruitless explorations in search of the Thick coal to the east of the shaft, they came back to it, and went up to a higher level, and followed a little two-inch coal in No. 5 towards the west, and that shortly led them into the Thick coal.

Examining these facts by the light of the information gained in exploring the Baremoor colliery (see page) we shall, I think, have little doubt that the Thick coal is cut off at West Bromwich on its eastern side by a large "rock fault;" that beds of sandstone with fireclay and clunch come in, suddenly splitting up the Thick coal, and almost entirely occupying its place, and that the coal in No. 5, together with those numbered 8, 10, and 12, in the section (page) are all ends or detached parts of some of the beds of the Thick coal.

The general course of the boundary of this rock fault is nearly north and south, as it was found again, with Silurian shale beyond in the same heading, at the Lewisham pits near Virgin's End, one mile north of the Heath pits, likewise cutting out the Thick coal towards the east, and overhanging with a general inclination of about 22°.§ Similar facts with regard to the ending of the Thick coal at a depth of 200 yards against some "rock and rig," were observed in some pits east of Lyndon near Hall End colliery, where there are no "red rocks" or Permian beds over the Coal-measures at all.

The most curious fact, however, is, that there is a sudden rise of the Silurian rocks both at the Heath and the Lewisham pits, through the Coal-measures; and this I am inclined to believe is not in consequence of any fault, but is due to their having formed an old Silurian bank of rising ground during the Coal-measure period, and that the Coal-measures were deposited against that bank, its existence being favour-

* By a jackey pit is meant a small occasional shaft sunk in any part of the underground workings for a particular and temporary purpose.

† I believe this hard rock was the one met with while the "Silurian System" was passing through the press. It was, from the description, supposed by Sir R. I. Murchison to be trap. It probably, however, was the upper part of the Dudley limestone, or possibly the Barr limestone.

‡ MS. notes of the evidence given by the men who were engaged in these operations, lent to me by Mr. H. Johnson.

§ The general inclination of the sides of the rock fault at Baremoor colliery was much the same, varying from 18° to 25°.

able to the formation of sandstone and the accumulation of clay, but unfavourable to the formation of coal. The extension of this "rock fault" and old Silurian bank is at present uncertain; it appears, however, either that they extend continuously for three miles to the south of West Bromwich, or that they recur at that distance near Langley Green, as we shall see hereafter when describing the boundary faults.

We have in these facts, then, an instance of the unconformity of the Coal-measures both to the Silurian below and the Permian above; and it is probable that a little further east of the Heath pits the Coal-measures are entirely wanting, and the "red rocks" of the Permian formation rest directly on the shale or "bavin" of the Silurian formation. This would then be one of those cases where the denudation of the Coal-measures had proceeded the length of totally removing that entire series of rocks previously to the deposition of the Permian beds. The whole history of the Heath pits gives us a good example of the value of geological knowledge to the practical miner; 1st, assuring him of the general fact of the existence of coal beneath the "red rock" of the Permian and New red sandstone formations; 2nd, putting him on his guard as to the possibility of coming down to a spot where the coal had been removed by denudation, showing him what he might expect as *possible* as well as what was *probable*, and teaching him what to do in any case.

We have now to examine the original relations between the New red sandstone and the Permian. These two formations seem likewise to be unconformable to each other, but we cannot yet exactly ascertain either the amount or the precise method of this unconformability. The possibilities of the case are,—

1st. After the partial denudation of the Coal-measures the Permian rocks may have been deposited, not uniformly over the whole district, but in large patches here and there, filling up hollows, but leaving bare the higher spaces of older rock. On this surface the New red sandstone might be deposited, resting sometimes on the Permian, sometimes directly on the Coal-measures, or perhaps on still lower rocks.

2nd. The Permian, after having filled up and levelled the old hollows in the Coal-measures, was continued, as to its upper beds, over the whole district. In that case those upper beds must have been again more or less denuded, as we now find the New red sandstone resting sometimes directly on the Coal-measures without the intervention of any Permian rock whatever.

This is the case at Brereton near Rugeley, where they have sunk in several pits through the quartzose gravel or conglomerates of the New red down into the Coal-measures, the two lying distinctly in an unconformable position, the coals cropping gently up into the base of the New red.

After attaining the New red sandstone there appears no further occurrence of unconformability, the beds appearing to lie with perfect parallelism and regularity through the red sandstones and gypsiferous marls up to the Lias of Needwood Forest.

CHAPTER X.

Position* and Lie of the Rocks.

General Description.

The South Staffordshire coal-field seems like an island of Palæozoic rocks rising up through the secondary New red sandstone plain of the centre of England. These rocks appear at the surface partly in consequence of their being elevated to a higher level than the Palæozoic rocks immediately adjacent to them, which are still covered by the New red sandstone, and partly in consequence of the New red sandstone, which once covered them also, having been removed by denudation.

The general form of the Palæozoic district is that of a rather rude and irregular spindle-shaped band slightly bent so as to have both its sides convex to the west, and terminating in a point both to the north and to the south.

These points are at Barnt Green, which forms the southern termination of the Lower Lickey range, and at "Brereton Coal Pits," near Rugeley. They are very nearly 26 miles apart, and bear about N. 7° E. and S. 7° W.† from each other. Neither this line, however, nor its bearing, is of any importance, or requires further notice in the description of the district.

There are, however, two lines which can be drawn within the Palæozoic area which are worthy of notice in themselves, and indicate bearings that are very important, giving us, indeed, the key to the structure of the district.

The first of these lines runs from Barnt Green to the termination of the Sedgley Silurian ground near Parkfield school, south of Wolverhampton. This line is 14½ miles long, and bears as nearly as possible N. 22° W., and S. 22° E.

The second line starts from the south-west angle of the coal-field near Pedmore, and terminates at the Brereton coal-pits before mentioned. It is 22 miles long, and bears N. 23° or 24° E. and S. 23° or 24° W.

These two lines intersect in the town of Dudley, where they cross each other at angles of about 45° and 135°. A line bisecting the angle of 45° would run as nearly as possible north and south. A line bisecting the angle of 135° would be as nearly as possible east and west.

The first line runs along the ridge of the Lower Lickey, and is parallel to the general direction of the boundaries of the southern

* By "position" is meant the place in or under which such and such rocks will be found, their depth from the surface, &c.; and by their "lie" is meant the form and manner of their occurrence, their angle of dip, their faults, &c.

† True bearings are always meant, unless when otherwise expressed.

part of the coal-field, to the Russell's Hall fault, to the greatest surface extension of the Rowley basalt, and to the general direction of the Dudley and Sedgley anticlinal.

The second line forms the axis of the Netherton anticlinal, runs nearly parallel to the Dudley Port Trough faults, to the outcrop of all the beds (both Coal-measures and Silurian), along the eastern margin of the district from West Bromwich to the Brown Hills, to the outcrop of the beds about Wyrley and Essington, to the western boundary fault north of Wolverhampton, and to the general direction of the northern part of the coal-field from Dudley northwards.

These two lines then point out to us the two directions along which the disturbing forces acted that have produced the principal inclinations of the rocks, and the principal fractures that traverse them. It may at once be seen by inspection of the maps that all the lines of outcrop and all the faults of any importance either run parallel to one of these lines of bearing or parallel to the lines which are their resultants, or those which lie half-way between them. That is to say, all the features mentioned above strike—

either N.N.W. and S.S.E.,
N.N.E. and S.S.W.,
N. and S.,
or E. and W.

All faults and all strikes that do not coincide very closely with one of those four lines of bearing are either small and unimportant, or occupy spaces that may be described as merely the connecting links where the one line of bearing is passing into the other.

Having thus sketched the outline of the framework of the district, let us commence our description of the lie of the beds at its southern portion.

The Permian rocks stretch in nearly horizontal and continuous sheets through the Clent Hills and the high ground of Hunnington and Romsley, Frankley Hill and Kitwell to Bartley Green. These beds dip with a very gentle inclination to the south. They are cut off both to the west and to the east by faults which afterwards form the boundary faults of the coal-field.

Towards the south these rocks have been largely denuded, especially in the middle portion south of Frankley Hill, where the surface of the ground dips more rapidly than the dip of the beds, and the rocks below the Permian are consequently exposed by the denudation. We find these rocks to consist of altered Llandovery sandstone and lower Wenlock shale and limestone, forming the broken anticlinal of the Lower Lickey, with a little unconformable deposit of Coal-measures on each side of it.

The Permian rocks and the beds below them soon, however, become concealed, both to the south-east, south, and south-west,

under the New red sandstone, either in consequence of their continued dip, or from their being suddenly thrown down by downcast faults in those directions.

If now we return to the high ground stretching through the Clent Hills and Frankley Hill, and descend its northern slopes towards Halesowen, we shall see that the beds of Permian rise gently to the north, and that at the foot of the slope the Coal-measures appear from underneath them. These Coal-measures consist, first of thin grey shales and clays, then of the Halesowen sandstones, and then of red clays, each successively rising out to the surface towards the north as we descend into the valley of the Stour.

We are here fairly within the coal-field which thence runs off continuously to the northward, or a little east of north, between its boundary faults, till we arrive at Hednesford and Brereton. The boundary faults are sometimes single large downthrows bringing the New red sandstone into direct contact with the Coal-measures, and are sometimes more complex, allowing of the appearance of more or less of the Permian rocks between the Coal-measures and New red sandstone.

At Hednesford and Brereton the two boundary faults seemingly run off into the New red sandstone, and over the space between them the Coal-measures are apparently covered by an overlap of the New red sandstone resting unconformably upon them. It is probable, however, that the Coal-measures are here, either let down by faults, or largely eroded under the New red, which formation probably thickens much more rapidly to the north than would be supposed by the mere inclination of the beds.

The coal-field then is a narrow plateau of Coal-measures bounded both on the E. and the W. by downcast faults, covered on the north by unconformable New red sandstone, and dipping on the south under apparently conformable Permian rocks.

The coal-field itself may be divided into two parts, each of which may be again subdivided into two.

The principal line of division in the coal-field is that which runs from Parkfield a little south of Wolverhampton, through Sedgley, Dudley, and Rowley, to the Leasowes. This line forms a broad anticlinal ridge from Parkfield to Dudley, round which ridge the coals all crop out, and on which the Silurian rocks rise to the surface at four places. Three of these, namely, Dudley Castle Hill, the Wren's Nest, and Hurst Hill form long oval elevations of the Dudley limestone, the axes of which run north and south, with the beds curving round at very high angles, but more broken by transverse dislocations than they seem to be at first sight. The fourth, namely, the Sedgley ridge, is a broader and more irregular synclinal flexure, the axis of which is likewise north and south, and which is also broken by faults.

South of Dudley this anticlinal form of the beds ceases, but the line of division is continued partly by the surface feature of the Basaltic hills and a steep western slope that runs from them to the south, but chiefly by a line of fault below the surface, having a great downthrow to the west-south-west, which we may distinguish as the Russell's Hall fault. To the south of the Basaltic range this line of fault appears as if again about to take an anticlinal form, since the Coal-measures rise sharply up to it from the west-south-west, if not from both sides. The line of division is then lost for a space, but re-appears again in almost exactly the same line of bearing in the narrow and broken anticlinal ridge of the Lower Lickey Hills (Rubury Hill and the Bilberry Hills).

We may speak of the part of the coal-field lying west of the line above indicated as the South-Western portion of the coal-field. It is subdivided into two by the Netherton anticlinal, a line 3 miles long running north-north-east and south-south-west, with the Silurian showing itself in its southern portion, and the coals cropping out on both its flanks and round both terminations.

The basin between the Netherton anticlinal and the Russell's Hall fault we may call the Cradley Basin. This basin seems to be comparatively free from faults, and except those that bound it has certainly no dislocations of great magnitude.

The basin lying between the Netherton anticlinal, Kingswinford, and Gornal we may call the Pensnett basin. This is traversed by a number of large and important faults that will be described more in detail presently.

Where the Netherton anticlinal ceases towards the north, there is a trough or hollow in the beds, nearly a mile wide, between it and Dudley, forming a channel connecting the Cradley and Pensnett basins. We will speak of this as the Old Buffery Trough, from the name of some ironworks situated in it.

The other principal part of the coal-field lies to the east and north of the main line of division before described. It is subdivided into two by the Great Bentley fault, which a little north of the latitude of Walsall runs across the coal-field from east to west, with a downcast of 360 feet (120 yards) to the north.

South of the Great Bentley fault lies the central and south-eastern part of the coal-field. The central is the part between the Dudley and Sedgley anticlinal and the Walsall Silurian district, both on the east and west side of which the Coal-measures successively crop out, and allow the Silurian rocks to appear from underneath them. They also rise, but much more gently, towards the north, the Thick coal, Heathen coal, and New Mine coal cropping out one after another in that direction, and the beds below them being at a very slight depth when they range up to the Great Bentley fault. This central district is traversed by many east and west faults, all having their greatest throw in the middle of their range, and all being downcasts to the south till we

come to the space south of Tipton occupied by the Dudley Port Trough. The pair of faults forming the Dudley Port Trough run parallel to, and almost in the same line with, the Netherton anticlinal. They tend, however, to produce a synclinal rather than an anticlinal effect, and the faults on each side of them aid that effect, since their downthrow is always towards the Trough. The faults running parallel to the Trough which strike from the northern flank of the Rowley Hills are mostly upthrows to the south-east till we approach the Brades, when they again have a southerly downthrow.

Beyond these the Coal-measures stretch into what we may call the south-eastern end of the central district, in which the beds lie nearly flat, as about Titford and Causeway Green, between the Rowley Hills and the eastern Boundary fault.

North of the Great Bentley fault lies the northern portion of the coal-field, in which the dip of the measures is at first steadily from east to west, at a mean angle of about 3°, gradually curving round till it dips west-north-west, and then apparently north-west at the same low angle, over Cannock Chase up towards Brereton. In the Old Park of Beaudesert, however, they appear to become first quite horizontal, and farther on at Brereton they are said to dip gently to the south-east, and to rise towards the north-west and crop up into the New red sandstone that lies upon them.

Many faults running chiefly east and west traverse the northern part of the coal-field, especially the part of it between the Great Bentley fault and Cannock Chase.

Trough Faults.—Besides the faults which have already been mentioned by name, there exists many others, some of which have been alluded to, in all parts of the coal-field. Their description must be left till we speak of them in detail, but it will be well first of all to call attention to those among them which dominate over the rest, and seem to bear to them a relation analogous to that which the keystone bears to the arch.

These are the Trough faults, of which we may enumerate six.

Two of these are in the Pensnett Basin, namely, the well-known Brierley Hill Trough, which runs nearly due east and west, and the less marked Tansy Green Trough, which, likewise, has a general east and west extension.

The central district has only one, but that is the largest and best marked of all, namely, the Dudley Port Trough, which runs nearly north-north-east for three miles, and then gradually curving round seems to merge into the system of east and west faults that traverse that portion of the coal-field.

The Great Bentley fault is itself the southern side of a trough, though of an unequal and imperfect character, since the amount of the upthrow of the corresponding fault on the northern side is only about one-fifth or one-sixth of the downthrow of the Great Bentley fault itself.

Besides these four, there are two very well marked, although only small troughs, which are known in the northern part of the field. The one is that of the High Bridge in the Pelsall district, and the other that which we may call the Rising Sun Trough, down the centre of which Watling Street runs from the old inn called the Rising Sun to the eastern boundary fault.

CHAPTER XI.

POSITION AND LIE OF THE ROCKS.

Detailed Description.

THE preceding chapter is intended for the use of the general geological reader, who wishes to gain merely a general notion of the structure of the district; read with the maps before him it may be sufficient for his purpose.

In this chapter it is intended to describe in a little more detail the features there sketched out, and to give some of the data on which the descriptions are founded.

We will first of all describe the main line of division before mentioned in Chapter X,. commencing with the northern part of it, namely, the Dudley and Sedgley anticlinal.

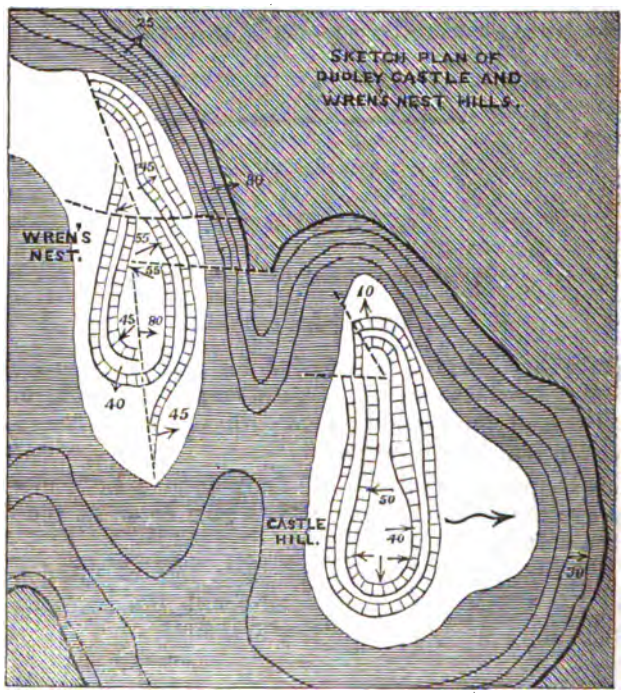
MAIN LINE OF DIVISION OF THE COAL-FIELD.

The Dudley and Sedgley anticlinal is not a simple one, but very complex. There is one general broadish area of elevation which may be said to be defined by the outcrop of the Thick coal. Ranged, however, on this wider and gently-elevated region there are three smaller areas that have each suffered from a maximum intensity of elevating force, namely, Dudley Castle Hill, the Wren's Nest, and the Sedgley district, including Hurst Hill. The axes of these three areas of maximum disturbance do not run parallel to the general axis of the elevated tract, but cross it very obliquely, running nearly true north and south. They would thus appear to be the result of the nearly equal action of the two prevailing lines of disturbing force before mentioned, as they run in a direction equidistant between them.

Dudley Castle Hill.—At Dudley Castle Hill the two bands of limestone rise boldly out on the south, at angles varying from 25° to 30°, curve round with great symmetry and regularity on each side, and stretch off to the north in a narrow ridge, the sides of which dip east and west respectively from its central portion, see Fig. 18. As they run north the inclination of the beds increases to 50°, and the two pieces of the lower limestone nearly meet each other on the crest of the ridge. On the east side the limestones begin at Shirts Mill to curve regularly round towards the north-west, dipping north-east, and then towards the west, dipping north at 10°, but are then suddenly cut off by a fault. The limestones on the west side are cut off by a fault

opposite Shirts Mill, and in the gap between these two ends a piece of the upper limestone only is seen at the surface of the ground, dipping about west-south-west.

Fig. 18.



Scale, 2 inches to a mile.

[" Dark part is Coal-measure ground, with dark lines for coal crops; the part obliquely shaded being above the Thick coal, that horizontally shaded being below it. Light part Silurian ground, with the limestones. Dotted lines are faults.

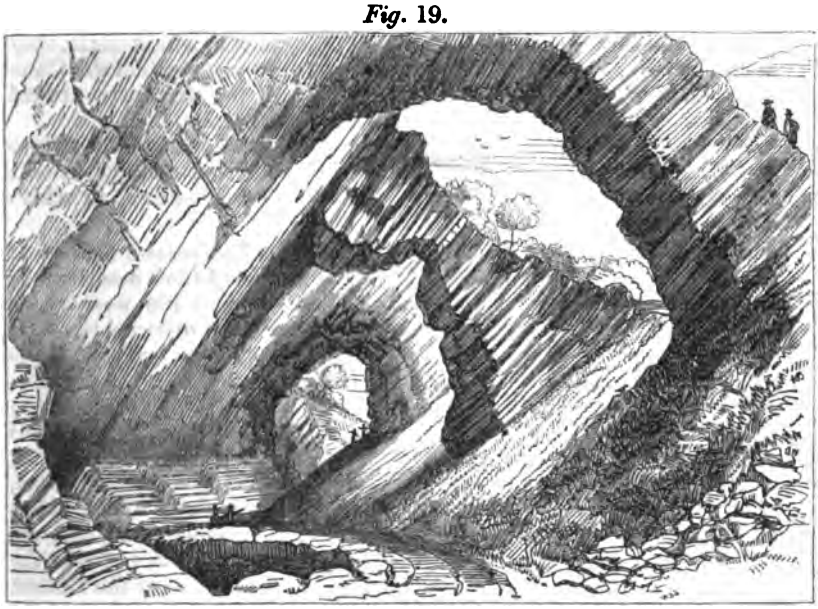
On the east side of the Castle Hill, between it and the Tipton road, the beds of limestone, after dipping from the hill for some distance, are found in the under-ground workings to flatten, and afterwards rise again towards the east, so that where the words "Castle-foot pottery" stand in the Ordnance map, east of the Tipton road, the limestone is reached by a shaft at the depth of only 52 yards (156 feet). From this point it again dips towards the east, at such an angle that in the space of 90 yards due east it becomes 112 yards deeps (336 feet).*

Wren's Nest Hill.—The Wren's Nest Hill is similar in general structure to the Castle Hill, but differs from it in some of its details. Like the Castle Hill, its general form is that of an oblong dome-shaped elevation, with a central nucleus of lower shale, on which repose the limestones, dipping every way at considerable angles from the centre of the hill. On the south-west side of the hill the beds curve round very symmetrically, dipping west, south-west, and south, at an angle of about 40°. Similarly on the north-east side the two limestones are symmetrically curved, dipping east and north-east, and finally almost

* This gives us a dip of 60 yards in 90 = 32°.

north at about 45°. Along the east and south-east sides of the hill, however, the inclination of the beds is much steeper, rising to 50°, 60°, and in one part upwards of 80°. At the south-east corner the beds, instead of bending regularly round, are broken through by a fault, so that the end of the upper limestone on the west of the fault is made to abut against the base of the lower limestone on the east side of it. The lower limestone of the east side is itself cut off by the fault a little farther south, but the upper limestone ranges some distance to the south alongside of the fault till, being finally traversed by it at a very oblique angle, it also disappears. The course of the fault towards the north may be traced a little way by the ending of the lower limestone on its west side, but it very likely runs up to the centre of the hill. From this spot a fault runs due east, cutting through the beds on that side of the hill, and shifting their outcrop 30 yards, so that the upper limestone on the south side of it is made very nearly to face the lower limestone on the north; from which it follows that this must be a very considerable downcast to the south, the beds north of it rising at an angle of 55°, those to the south at one of 80°.

Fig. 19.



Caverns, West Side of Wren's Nest.

About 250 yards north of this another east and west fault cuts right across the ridge, fracturing the beds on the east side, and entirely cutting off those on the west.* From the centre of the ridge where it is traversed by this fault another is supposed to spring, running north-west, in order to account for the sudden ending of the two limestones in that direction as they curve round from the north-east side of the hill.

* It is worthy of remark that these faults in the Wren's Nest and the other Silurian elevations do not appear to affect the Coal-measures, although it is clear that these dome-shaped elevations did not take place till after the Coal-measures were deposited. It is plain, therefore, that the cracks and fissures of the dome-shaped elevations are strictly local, or have not much longitudinal extension.

Between these two last faults, on the north-west side of the ridge, a piece of the upper limestone only reaches the surface, just as a similar piece did between the two faults on the north-west end of the Castle Hill.

In the valley between the Wren's Nest and the Castle Hill repose the lower beds of the Coal-measures, the Bottom coal running some distance into it, both from the north and south ends of it.

Coal-measures likewise stretch between the Wren's Nest and the Sedgley Silurian district, but these are only the sandstones forming the base of the formation, and *they* lie only on the higher parts of the ground, the bottom of the valley north-west of the Wren's Nest showing Silurian shale at the surface.

The Sedgley District is rather a complicated one.

Hurst Hill.—On the east side of it is Hurst Hill, where the Wenlock and Dudley limestones rise into a long oval anticlinal ridge, like those of the Wren's Nest and Castle Hill, but not so perfect. At the southern end the two limestones bend round and abut against the base of a piece of the upper limestone, a fault running between the two; this piece of the upper limestone must be cut off each way by faults, and a fault dropping down to the west runs along the whole of the remainder of that side of the ridge, preventing the appearance of the limestones. On the eastern side the beds strike north, dipping east at a high angle, they are broken through by a small east and west fault just south of the Cann Lane road, but from that spot strike still north till they curve round the northern end of the ridge, and dip in that direction.

They have been followed under ground north of the hill for 200 or 300 yards, dipping generally north at about 30°, and ending towards the west against a fault which runs about north-north-west, and which must be a downcast to the west.

Sedgley Beacon.—West of Hurst Hill is a rising ground formed of the Ludlow rocks, containing the band of limestone before described as the Aymestry and Sedgley limestone. These at first dip west at an angle of 10° to 20°, forming a pretty bold escarpment towards the east known as Sedgley Beacon Hill. The limestone, however, soon rises again to the west, and forms a cap to the high ground south of Sedgley, and after undulating a little in various directions, finally crops out on the west side of the hill, dipping east at 10°. North of Sedgley this cap does not appear, the Silurian beds forming a basin instead of a cap, and only cropping out on the west side of the Wolverhampton road, where they dip pretty regularly to the east at an angle of 20° for about half a mile. They then appear to curl over for a short space, and dip north-west at 35°, but I believe this is only a local flexure, and that the limestone beds curve round from this point to meet those of the Beacon Hill quarry. About one third of a mile north of that, however, the limestone again appears suddenly at the surface, dipping north-east at 60°, its northern end curving round till it dips north and north-north-west, at 15° and 20°, and then suddenly ending. The faults drawn on the map are the most obvious explanation of this peculiar position of the rocks, though with the exception of the one on the west side of Hurst Hill, they are all put in hypothetically. In the hollow of the Silurian rocks north of Sedgley the sandstones forming the base of the Coal-measures again occur, as shown on the map. About half a mile south of Sedgley the Silurian rocks must be cut off by an east and west fault, a downcast to the south, which brings in the Coal-measure sandstone on their level.

Turner's Hill.—These lower sandstones spread over the ground from Upper Gornal, by Ellows Hall, to Lower Gornal, undulating in various

directions, and at Turner's Hill, west of Lower Gornal, a patch of the Silurian with a band of Aymestry limestone again makes its appearance from under them. There is, however, but one small quarry in it, and the exact details of the structure of the country just hereabouts are very obscure.

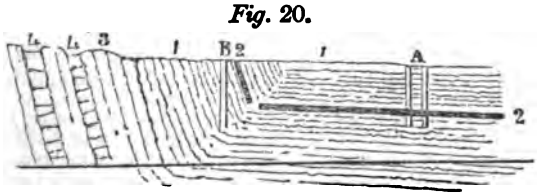
Coal, supposed to be part of the Thick coal, has been found and partially worked in the valley, which runs from the west side of Sedgley down by Cotwall End. It was, however, much broken and disturbed, but was said to dip generally to the west, and frequently at very high angles.

At Sedgley Hall farm a trial pit was sunk in 1828, in which they passed through 120 feet of "red croprash rock and marl," under which were 200 feet of Coal-measures, and then the Thick coal dipping west at an angle of 12°. As there is no sign of the Thick coal cropping out between this spot and the Silurian ridge, there must be a fault between, which makes it probable that a fault forms the west boundary of the whole of the Sedgley Silurian district.

Outcrop of the Coals round the Dudley and Sedgley anticlinal.—We will now briefly trace the outcrop of the coals round this singularly dislocated district of elevation. Beginning on the south of the town of Dudley, the Thick coal and the beds just above and below it crop regularly out, dipping south at an angle of about 25°. The crop of the Thick coal may be traced very easily, partly by the old, partly by the present workings across Dixon's Green, and a little north-west of the Freebodies to Burnt Tree, when it dips east at 30°, and thence curving round the Silurian tract of the Castle Hill to the angle between it and the Wren's Nest. Along the north-east flank of the Wren's Nest the Thick coal is nearly vertical, and was worked in an open quarry in the years 1849 and 1850.*

* As a good illustration of the very careless and ignorant manner in which the South Staffordshire coal-field has been worked, I will describe the way in which this vertical piece of coal was discovered. A little to the east of it the Thick coal had been worked continuously in a nearly horizontal position at a depth of about 70 or 80 yards, as at A, Fig. 20. The workings were continued towards the Wren's Nest till the coal ended against a fault or supposed fault, or at all events, some "troubled ground." A shaft, B, Fig. 20, was then sunk from the surface, about 30 or 40 yards to the west of this supposed fault, in search of the coal. No notice could have been taken, in sinking this shaft, of the angle at which the beds inclined, and after being continued for more than 70 yards it was abandoned. In fact it must have been sunk the whole distance nearly along the same bed in which it was begun, the beds being nearly vertical, but that was not observed, or not understood, neither were the beds below the Thick coal recognized. The lease of the land was on the point of being given up by the gentlemen who held it, when, a few feet of rubbish being accidentally removed from the surface at a particular spot, the end of the Thick coal was uncovered and of course worked. Even then, however, the ground bailiff, whom I met on the spot, and who had charge of all the mining operations, seemed scarcely to understand that this was merely a piece of the Thick coal bent up into a nearly vertical position, and broken off the horizontal portion below, as shown in diagram, Fig. 20.

Fig. 20.



A. The old shafts.
B. The new shaft sunk in search of the coal.
1. Coal-measures.
2. The Thick coal.
3. Silurian shale.
4. The Limestones of the Wren's Nest hill.

The coal strikes regularly from this spot to the Foxyards, where it flattens very rapidly to a nearly horizontal position.* It was formerly worked here also in an open quarry. Hence, after bending a little into the hollow between the Wren's Nest and Hurst Hill, the crop of the Thick coal runs along Ettingshall lane nearly up to Monmore Green.

A little south of Catchem's Corner it is broken through by the branches of the Great Lanesfield fault, which traverse likewise the lower beds to the west of it. Here, between the Ettingshall Park farm and Monmore Green, there is a very broken and disturbed district of Coal-measures. It appears that a rude anticlinal curve runs north from Hurst Hill by Ettingshall Park farm, the Parkfield furnace, and the Rough Hills colliery. The New Mine, Fire-clay, and Bottom coals, after rising to the west, flatten, curve round, and dip again to the west; and a fault running north and south by the Wolverhampton furnaces, has a downcast to the west of about 150 feet, and brings in a good sized patch of the Thick coal in that direction, which dips north-west and west at an angle of 30° towards the red rock of the Permian formation. South of this, on the west side of the Parkfield colliery, the Coal-measures are completely smashed up by faults, and contorted in so violent a manner that, as I was informed by Mr. Smith of the Priory, one shaft passed through the Blue-flats ironstone three several times, first meeting it with the top bed uppermost, but dipping at a very high angle, then with the bottom part uppermost, also at a high angle, and then again with the top side uppermost and nearly horizontal, the beds being curved into the form of an S. It was quite impossible to represent on the very inefficient scale of the Ordnance map anything at all approaching to the complicated faults and contortions of this piece of ground; but a few of the principal have been drawn with a tolerable approach to accuracy. They show that the action of the disturbing forces did not end merely in producing the Silurian elevations lately described, but was continued into the Coal-measures to the northward, and may have extended still farther for an unknown distance, producing fractures and dislocations in rocks now buried under the Permian and New red standstone rocks on the north-west.

Returning now to the south of Dudley, the outcrop of the Thick coal may be traced by the old workings along the south-west side of the town up to Shaver's End and Russell's Hall. It dips at a gentle angle to the south-west, not exceeding in any case 20°, and rarely so much as 10°, and as the ground likewise slopes rapidly in that direction, the Thick coal does not at first acquire any great depth, and its outcrop is deeply waved and indented by the valleys and hollows of the surface.

Thus the little valley north of Russell's Hall completely cuts down through the Thick coal into the lower measures. As the ground on the opposite side of the valley, however, called Dipdale Bank, rises to a sufficient height, it again brought in a large patch of Thick coal that extended nearly up to Gornal, where the ground slopes the other way. This piece of Thick coal being in no place more than 20 yards deep, has long been worked out.

These men have a fixed idea *that coal grows*, that it is still growing and forming in the earth, and that not only the coals and ironstones grow, but that the *faults grow likewise*; it is not possible, therefore, that they can have any clear ideas of their work, or be able to adapt it to any unusual circumstances.

* At the Foxyards a ground bailiff informed me that the Thick coal there was not the same as the Thick coal just mentioned, his only reason being that a parting of shale was a foot thicker in one place than in the other; he said there must be a fault between them on that account!

The Russell's Hall fault.—On the south-west side of this indented outcrop* of coal runs the long Russell's Hall fault, which here throws down the Thick coal and other measures 120 feet to the south-west. Owing to a local flexure and rise of the beds, however, the Thick coal again crops out round Gornal Wood on the downthrow side of the fault.

The Russell's Hall fault running on the south-south-west side of the Sedgley and Dudley ridge, is continued to the south-east along the south-west flank of the Rowley Hills. It holds its course very regularly towards the south-east, its "throw" increasing as we proceed to the southward, up to 150, 180, and 240 feet, and eventually, near Rowley Regis, it has a downthrow to the westward of upwards of 400 feet. Beyond this its details are not accurately known, but at Coombs Wood it was partly proved by Mr. W. Mathews, and it seemed as if the fault were there passing into a very sharp anticlinal curve, as he found some Thick coal on the west side of it only 16 yards from the surface, and dipping at a high angle to the west, in which direction it acquires a depth of 750 feet in the space of a mile. On the east of the fault line it is known also to be 570 feet deep at a similar distance.

Near the foot of Mucklow Hill, a disturbance, probably due to this fault, may be seen in the Coal-measure sandstones, which dip 3° to the east on one side of it, and 30° or 40° to the south-west on the other. As the beds seem nearly, if not quite similar, it is probable that here also it is rather a rude anticlinal than a clean-cut fracture or fault.

The Rowley Basalt.—It is remarkable, that where the Sedgley and Dudley anticlinal ends, the mass of the erupted basalt of Rowley begins, and that hereabouts the Russell's Hall fault has its greatest amount of "throw," and is most of an actual fracture, while a mile south of the Rowley basalt the dislocation appears to be on the point of passing again into an anticlinal ridge. This almost looks as if there would have been a continuous anticlinal elevation all the way from Sedgley to the south end of the Lickey had it not been for the eruption of the Rowley rag. If the eruption of the Rowley basalt could be shown to have been subsequent to the formation of the whole Coal-measures, and contemporary with the fractures and dislocations of the coal-field, it might readily be accepted as a *vera causa* for the gap between the two anticlinals mentioned above. We should then suppose that the strain acting on the beds was relieved at one point by the actual outburst of trap, while in others it resulted in the uplifting and protrusion of the inferior rocks.

I believe, however, that this apparent connexion between the occurrence of the Rowley basalt and the dislocations and lie of the Coal-measures is an apparent and accidental one only. The change from a bold anticlinal to a mere depression, with a fault on one side of it, I think is due to the fact of the Dudley Port Trough faults cutting across the course of the anticlinal. These faults actually dislocate the Rowley basalt, which must, therefore, have been solid at the time of their formation.

* Mr. J. Kenyon Blackwell was kind enough to accompany me in tracing the crop of the Thick coal hereabouts, with his ground bailiff, Mr. Waterfield. The outcrop of the coal was perfectly well marked by the occurrence, at the surface of the ground of fragments of "shattery." This is the local name for a well-known indurated shale, streaked red and green, and baked almost into jasper. After extracting the coal, the fragments of coal and shale are piled up in the hollows to afford a partial support to the roof. This mass of fragments is called the "gob," and in shallow excavations, where the air and water from the surface find ready access, it frequently takes fire, and burns for a very considerable time with a slow combustion. Just at the west entrance of the town of Dudley, in a cutting of the road, smoke and steam may often be seen in damp weather rising through the joints and cracks of a sandstone rock, from the combustion of the "Thick-coal gob" below.

It is, however, quite possible that the existence of the Rowley basalt and of the net work of dykes and veins of trap below it, was one of the reasons why the Dudley and Sedgley anticlinal was not continued to the south-south-east. The rocks beneath the basalt may be so bound and laced together by this net work of trappean braces, that the forces of elevation, whatever they were, were unequal to the task of bending them up into symmetrical curves and dome-shaped elevations like those of the Castle Hill and the Wren's Nest, &c., and left them, therefore, comparatively undisturbed, except by fractures and dislocations, some of which we can trace, but of which many more probably exist than we are yet aware of.

I believe, therefore, that here, as elsewhere, wherever I have had an opportunity of making accurate observations, the mere intrusion or outburst of igneous rock has had little or no immediate connexion with the dislocations or elevations of the rock.

Following the direction of the line of the Russell's Hall fault south of Mucklow Hill, we find an interval of several miles in which no observations can be made.

What may be the position of the Coal-measures below the Permian beds of Frankley Hill we of course have no means of ascertaining; but on the south side of that ridge a few Coal-measures with a little coal showed themselves, on each side of the quartz range of the Lickey, in a nearly horizontal position. These beds may stretch continuously and horizontally under the Permian, from the valley south of Halesowen, and become exposed at the Lickey by simple denudation, in which case they are probably very high Coal-measures, or they may be the lowest Coal-measures brought up either by the rise of the beds or by dislocations concealed under Frankley Hill.

The Lickey Hill anticlinal.—If, however, we follow the direction of the southern half of the Russell's Hall fault, namely, about south-south-east, we shall strike in about 4 miles on the linear elevation of the Lickey quartz rock, which likewise has the character of a broken anticlinal. This fault, therefore, connects, if only in a vague way, the two *anticlinal ridges* of which the axes both run north-north-west and south-south-east, that, namely, of Sedgley and Dudley with that of the Lower Lickey.

The quartz rock of the Lickey is greatly broken and fractured, and in some cases violently contorted. At the northern end, about Holly and Rubury Hills, and by the New Road, it dips easterly at from 10° to 20°. Near the old Rose and Crown it dips west at 35°. In the quarry opposite the Reservoir it is violently contorted. At the south end limestone was formerly got, and there seem to be some softer shaly beds thereabout, which are doubtless the bottom beds of the Wenlock shale. It is believed that the eastern boundary of the quartz ridge south of the Colmers is a fault, with a downthrow to the east. North of the Colmers soft shaly beds, with calcareous bands and Silurian fossils, have been got on each side of the ridge, just underlying the Coal-measures.

We have doubtless here the very same beds that occur about Shustoke Lodge and near Hay Head, namely, the Llandovery sandstone locally altered into quartz rock and thrown into a small anticlinal ridge, with the bottom beds of the Wenlock shale and calcareous bands representing the Barr limestone covered unconformably by thin skirtings of Coal-measures. The Permian beds near Barr seem to be brought in solely by a fault, though perhaps even that is doubtful, while at the Lickey there is no occasion for any such supposition, since they seem simply to have covered up all the other rocks unconformably,

and to be now partly removed from off a certain space by simple denudation.*

The following diagram, Fig. 21, represents the probable relations of these rocks.

Fig 21.

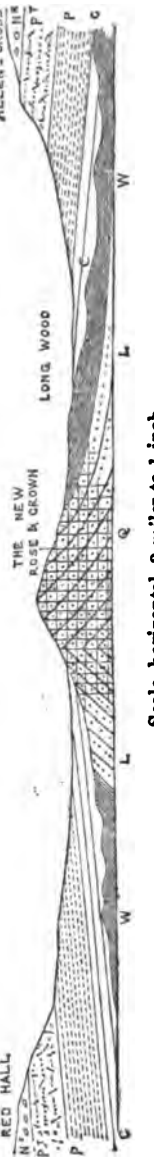


Fig. 21.

Diagrammatic Section across the Lickey, through the Long Wood, and by the new Rose and Crown.

Scale, horizontal, 2 miles to 1 inch.

Nr New red sandstone.
Pt Permian trappean breccia.
P Permian red sandstones and clays.
C Coal-measures.
W Wenlock shale
L Llandovery sandstone converted into Q. quartz rock over a certain space in the centre.

* Professor Ramsay, however, informs me that subsequent careful examination made by himself led him to the conclusion that the ridge of the Lickey, formed of quartz rock, was everywhere bounded by a fault, as shown in the later editions or the maps. My own notion still is that the appearances may be accounted for by the overlap of the different subdivisions of the Red rocks among themselves, and their total unconformity as a whole to the rocks below.

THE SOUTH-WESTERN PART OF THE COAL-FIELD.

Having described the line of division which separates the south-western from the central portion of the coal-field, let us now examine the lie of the rocks in that south-western portion.

It was shown in the last chapter that this was partly separated into two basins by the Netherton anticlinal.

The Netherton anticlinal.—A little east of the village called the Lye, near Stourbridge, is found a protruding mass of Ludlow shale, with a band of limestone like that before noticed at Turner's Hill and Sedgley. It dips east at 40°, but after running north of the road for almost a quarter of a mile, it suddenly ends, being probably cut off by a fault. Immediately south of the road it terminates somewhat in the same way.

In the cutting of the road the Silurian shale may be seen dipping east at 40° for about 30 yards above the limestone; there are then 9 yards of Coal-measure sandstone, with ironstone balls, dipping in the same way, and 100 yards east of that the bottom beds of the Thick coal may be seen dipping west at 65°, or towards the limestone. The Thick coal must, therefore, be reversed, or bottom upwards. In the Hays coal-pits, just east of this, the Thick coal is found greatly broken and disturbed, dipping generally east, at a high angle, and then suddenly assuming a nearly horizontal position, in which it continues some hundred yards to the eastward.*

From the Hays the crop of the Thick coal may be traced about a quarter of a mile to the south-south-west, when it curves suddenly to the west, dipping south at a considerable angle. On the other side of the Lye the Thick coal comes in again dipping west, and on this side the outcrop of the coal may be traced some distance to the south-west, when it appears suddenly to come to an end.

In the brook between these two terminations of the Thick coal some Coal-measures may be seen dipping to the south, it is, therefore, very probable that the apparent termination of the Thick coal outcrop to the south-west of the Lye is due merely to a sharp flexure and change in its strike, and that it turns suddenly to the eastward and joins that coming towards it from the other side of the anticlinal. The Netherton anticlinal will in this way terminate to the south with a regular sweep of the beds across the direction of its axis in the same way that it ends to the north.†

From the Lye to Netherton church the anticlinal runs very steadily to the N.N.E., the Thick coal dipping on either hand at an angle of about 20° to 25°, and its outcrop quite easily traceable by the old workings. Just north of Netherton church the anticlinal dies away, the two outcrops meet, and the Thick coal dips north till it flattens and rises again towards Dudley.

In the centre of this anticlinal, in the canal tunnel and cutting near Yew Tree Hill, is exposed a remarkable mass of basalt or greenstone

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* I was informed that in one shaft the Thick coal was actually bent over near the outcrop, so that the same vertical pit passed twice through the Thick coal.

† Owing to imperfect and apparently erroneous information, a different direction was given in the first edition of the map to the outcrops of the coals at the south end of the Netherton anticlinal, and they were supposed to separate and spread till cut off by a fault. I owe the correction of this mistake to Mr. T. King Harrison of Stourbridge, and his ground bailiff, Mr. John Hatton. The same gentlemen also pointed out to me that the Thick coal of the little basin of the Grange (farther west), although it cropped up towards and into the boundary fault, never actually cropped at the surface, as I had been led to suppose when formerly surveying the ground.

which sends out veins into the adjacent Coal-measure sandstone, and is therefore intrusive. It is not at all necessary, however, to look upon the intrusion of this mass of trap as contemporaneous with the formation of the anticlinal elevation.

The Cradley Basin.—It appears from former and recent information that a fault runs parallel to the Netherton anticlinal on the eastern side of it, from Careless Green to the neighbourhood of Musham. I believe this fault, however, to be merely a fracture, with but a slight displacement, in the Thick coal and other measures where their "lie" changes suddenly from a nearly horizontal to a highly inclined position.

From this line of disturbance they appear to stretch across very uniformly and nearly horizontally under Cradley Heath, Congreaves, and High Haden, as also under Dudley Wood and Old Hill, till they reach the Russell's Hall fault before described, when they are suddenly bent up at a sharp angle as well as broken and heaved to a height of 300 or 400 feet.

A few small faults are met with about Baremoor and Congreaves, as shown on the map, and another small east and west fault runs through the Hawn Colliery with a downthrow of 30 feet to the south.

As the beds dip to the south, while the ground rises rather rapidly in that direction, it follows that the uppermost beds of the Coal-measures must soon make their appearance. We accordingly find the Halesowen sandstone group stretching across the coal-field from east to west, and above those we soon meet with the red beds of the Permian formation.

On the road from Halesowen to Hagley two considerable patches of Permian rock are seen to rest on the upper sandstones of the Coal-measures; one at Quarry Hill and Hasbury, and the other at Hayley Green. These Permian beds dip to the southward; but in the brook immediately south of them good Coal-measure beds can be seen, and farther south in Uffmoor Wood one, if not two, little coals have been found, and may be seen cropping into the brooks. It is clear, therefore, that these two Permian outliers are cut off to the southward by a fault which is an upcast to the south, and runs about east-north-east and west-south-west along their southern boundary.

The southern boundary of the coal-field stretching from Wychbury Hill on the west, to Lappal tunnel on the east, is formed by the horizontal beds of the upper Coal-measure sandstones and shales becoming covered as we ascend the rising ground to the south, by the horizontal beds of the Permian rocks.* It will be seen accordingly, by inspection of the map, that this boundary, instead of being smooth and regular, like that of the east and west sides of the coal-field, is indented and undulating, depending chiefly on the shape of the ground. Wherever a valley sufficiently deep penetrates to the south, there is a bay of Coal-measures marked in the map. Wherever a ridge sufficiently high stretches to the north, a promontory of red rock will be seen advancing in that direction. We have here, therefore, a true natural surface boundary of the coal-field, caused simply by the irregular denudation of the rock that covers it.

Pensnett Basin.—The Pensnett Basin is bounded by the Netherton anticlinal on the south-east, the south-western slopes of the Dudley and Sedgley ridge, and the northern part of the Russell's Hall fault on the north-east and the Western Boundary fault on the north-western and south-western. Instead of declining gently to the north and passing

* By horizontal is here meant "apparent horizontality" only. There may be a slight dip to the southward of 2° or 3°, every geologist knowing that it is impossible to detect such a slight variation from horizontality with anything approaching to certainty or accuracy, except under very favourable circumstances.

under the Permian, as in the Cradley basin, the beds of the Pensnett basin rise and crop out to the south, not only along the flanks of the Netherton anticlinal, but over great part of the ground between it and the Boundary fault.

Immediately west of the Lye, indeed, there is a little basin of Thick coal which under the Grange is at a depth of 140 yards, and seems to dip thence rapidly southwards towards Prescott, as was before described, when speaking of the south end of the Netherton anticlinal. It not only dips south, however, but rises rapidly towards the west at an angle of 45°, and cropping against the boundary fault for some distance it reaches the surface just south of the Stourbridge road, whence this outcrop strikes north-easterly, and runs parallel to the Netherton anticlinal for some distance, thus making the little trough of Hay Green and Tintam Abbey.

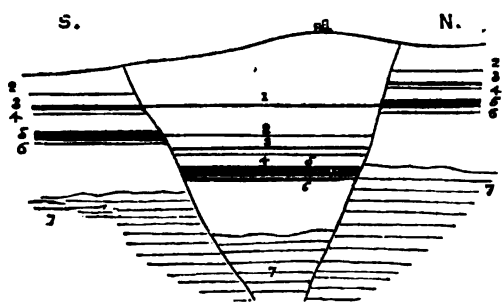
The Thick and other coals, however, are so much deteriorated here by "rubbish" that the clays become the more valuable mines, especially the Fire-clays used for making the well-known Stourbridge fire-bricks.

After striking north-easterly up to Mousehall farm the crop of the Thick coal then curves to the west towards Amblecote, and runs in a curved line to the boundary fault a little south of Brettell Lane, as shown in the map. All along this line the dip is to the north under Brierley Hill.

A few little east and west faults traverse the Amblecote and Hay Green district, and are said to extend even across the anticlinal.

Fig. 22.

Brierley Hill Trough Faults.



Scale 6 in. to 1 mile, vertical and horizontal.

1. Upper Sulphur coal.
2. Two-foot coal.
3. Broach „
4. Herring „
5. Thick coal.
6. Heathen coal.
7. Silurian shale.

Brierley Hill Trough Faults.—At Brierley Hill two much more powerful dislocations form a trough, each having a downthrow of 80 or 90 yards (or about 250 feet), in the centre of their range, but decreasing that amount towards their extremities to less than 30 yards (or 90 feet). The southern of these two faults ends on the west flank of the Netherton anticlinal, but the northern one is said to run right across it, carrying a downthrow to the south of 10 or 12 yards, and running in a curved line to Withymere, where it dies out on coalescing with the Russell's Hall fault.

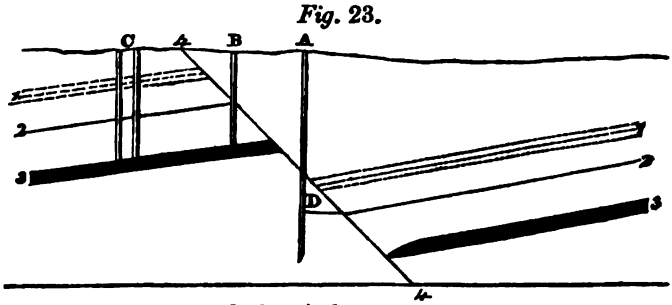
Brockmoor Fault.—On the west both these faults are cut off by the southern end of the Brockmoor fault, which, springing out of the western boundary fault north of Brettell Lane, runs about north-north-east to Pensnett reservoir, having a downthrow to the west of about

300 feet. This fault sends out two slight branches, one to the east by the Round Oak, with a downthrow to the south of 5 yards; one to the north-east through Hart's Hill, with a downthrow to the south of 10 or 8 yards. At Pensnett reservoir the Brockmoor fault is believed to branch as shown in the map.

I was informed by Mr. Pearson, of Brierley Hill, that "at Brockmoor this fault threw down to the west 130 yards, or nearly 400 feet, that it was only *a slip*, but was 200 yards wide, or made that much barren ground." The meaning of which description is, that although the fault itself had no apparent thickness, yet the two ends of the Thick coal were separated by 200 yards measured on the surface of the ground, showing the fault to have an inclination of not more than 33°.

Corbyn's Hall Fault.—The Corbyn's Hall fault strikes out of the Great Boundary fault about a mile north of Bugpool, a little west of Salter's Hall. Its downthrow is likewise to the west and north, at first 360 feet, diminishing then to 300, which it maintains for upwards of a mile. It then curves gradually round to the north-east by Shut End House, diminishing its throw to 240 feet, and thence passing through the north end of Barrow Hill by Hunt's Mill, it strikes east up to Russell's Hall iron furnaces, its downthrow being north 120 feet. I believe this is the fault mentioned by Sir R. I. Murchison in the Silurian System, p. 504. He gives a section of it on the authority of Mr. W. Mathews, in which there is an actual dyke drawn, 140 yards in width, between the broken ends of the coal. Mr. Mathews derived his information from his ground bailiff of that time, but on cross-questioning his present ground bailiff, Mr. Job Taylor, I arrived at a different and more natural explanation of the facts. I may premise, that in South Staffordshire, by the "width" of a fault is always understood *the width measured at the surface of the ground*, between the broken ends of the Thick coal, or any other bed that may be worked. It is the space of barren ground as to that particular bed, the width of which is measured in yards on the mining plan. It depends, therefore, not on the actual or real width of the fault, but solely on the angle of its inclination. This will be seen from the following account:—Job Taylor first assured me that this was not *a fault* at all, but only *a slip*, by which he meant that there was no real width or substance in the fault. He then told me that the "throw" of the fault was 90 yards, and its "width" was exactly the same, as in the following diagram (Fig. 23):—

Fig. 23.



Scale, 1 inch = 150 yards.

A, B, C. Shafts.	D. Gate-road.
1. Beds containing water.	3. Thick coal.
2. Brooch coal.	4. The fault.

A shaft (A in the diagram) was sunk, which crossed the fault between the ends of the pieces of Thick coal, and was therefore said to be sunk in the fault. But from this shaft they drove out a gate-road (D), and

on the deep side they hit the Brooch coal *in advance* of the Thick coal, as in the diagram. Moreover, there were certain wet beds (1 in diagram), beds from which water came out, above the Brooch coal. Now, in a shaft (B) sunk to the Thick coal on the crop side of the fault, these beds were not passed through, and the shaft was quite dry; while in the shafts (C) further from the fault, they were met with, and the shafts were quite wet. This likewise agrees with the diagram, and the facts are explicable only on the supposition of its correctness. Job Taylor likewise assured me that on the deep side of the fault the coal was "pinched" towards the fault by the descent of the roof, as in the diagram. If the reader will draw perpendicular lines from the ends of the Thick coal No. 3, where they are traversed by the fault, up to the surface, the space between those lines will give him the width of the fault according to the common notions of it.

*Shut End faults.**—A little north-west of the commencement of the Corbyn's Hall fault, two parallel faults strike nearly north from the Boundary fault near the Standhills, one throwing down to the west about 300 feet, another up to the west 150 feet, with a complicated and broken piece of ground between them. They coalesce or come very near together, just south of the Dudley and Kingswinford turnpike road, and thence proceed as one fault north-by-east, just west of the Shut End furnaces, with a total downthrow to the west of 180 feet. This fault, called the Shut End fault, is believed to run by Askew bridge up to the Russell's Hall fault there.

Taney Green Trough.—It sends a considerable branch from Shut End by Cooper's bank, nearly to the Graveyards, which has a downthrow to south-east of about 120 feet. This branch forms a trough with the northern or north-eastern extension of the Corbyn's Hall fault, both running nearly east and west, and having a downthrow of about 90 feet towards each other.

Even at Shut End the fault is not a single fissure, like the Corbyn's Hall fault, but a wide dislocation made up of a number of steps or smaller fractures (see Horizontal Sections, Sheet 25, No. 7). Mr. Colly, the ground bailiff, was kind enough to give me the details of a gate-road that was driven through the fault, starting from the Thick coal on the "crop" side of it, *i.e.*, the upcast side. The gate-road was horizontal, but they met, in driving, with beds lying at various angles, of which the following are the details:—

	FT.	IN.
1. Coal and batt	9	0
2. Rock binds	42	0
3. Rock	12	0
4. Peldon	21	0
5. Rock binds	33	0
6. Pin measures	12	0
7. Herring coal	6	0
8. Bind measures	9	0
9. Brooch coal	34	6
Carried forward	178	6

	FT.	IN.
Brought forward	178	6
10. Rock binds	8	0
11. Herring coal	9	0
12. Bind measures	9	0
13. Brooch coal	9	0
14. Fire-clay	9	0
15. Two-foot coal	6	0
16. Red ground	33	0
	261	0

This red ground No. 16 was outside of the faulty ground, and at the end of the 33 feet they sank a "jackey pit," and found the Two-foot coal which they had just previously passed through lying horizontally 22 feet below them. The whole length of the gate-road was 261 feet,

* Mr. B. Gibbons, of Shut End House, described this piece of ground to me from his mining plans.

during which they twice passed along the same set of beds, rendering it probable that there was an upcast between the downcast faults. Had the dip of the several fragments of beds been given, we might have constructed a very instructive section of this gate-road.

Gornal Wood faults.—Between Gornal wood and the Graveyards there are four faults which strike south-south-west out of the Russell's Hall fault, each having a downthrow of 21 feet to the east-south-east.

It will be seen that not only these, but the other principal faults, namely, the Shut End, Corbyn's Hall, and Brockmoor faults, have likewise a general bearing of north-north-east and south-south-west where their throw is greatest and most decided, and that where they deviate widely from that bearing is where they send out branches that eventually become east and west faults, or where perhaps such faults merge into them.

These east and west faults have generally a less amount of dislocation than the others, the only large throws being in the pair of faults that make the Brierley Hill Trough, and these are only important with respect to the piece of ground which lies between them.

The general effect of the three great north-north-east and south-south-west faults, the Brockmoor, the Corbyn's Hall and the Shut End, is to throw down the measures towards the west, and extend the coal-field in that direction. If it had not been for these breaks it seems likely that the outcrop of the Thick coal south of Brettell-lane might have run in a straight line north-north-east for that north of Turner's Hill by Cotwell End and Sedgley Hall farm.

If the coal had not cropped out along that line, it is at all events very probable that the western boundary fault would have run along it with one great heave of a downthrow to the west bringing in the Permian or New red sandstone beds against the Coal-measures.

Instead of one great heave, we may look upon these three faults as subdivisions of the boundary fault, letting down the coal measures by a succession of steps towards the west before burying them under the other formations.

Between Netherton and Dudley the two basins of Pensnett and Cradley coalesce, the coals and the principal dislocation,—the Russell's Hall fault,—ranging uninterruptedly from one to the other, and the beds dipping north from the end of the anticlinal till they rise to the Russell's Hall fault.

THE CENTRAL AND NORTHERN PART OF THE COAL-FIELD.

We now come to the part of the coal-field which lies east and north of the main line of division. Before describing the position of the Coal-measures, however, it will be as well to give an account of the Walsall Silurian district and show the connexion between the beds there and those which have been already described as appearing on the Dudley and Sedgley anticlinal.

The Walsall Silurian district is of very irregular shape, owing partly to the action of several faults, partly to the overlapping of the Coal-measures. In the cutting of the South Staffordshire railway on the west of the town may be seen the calcareous beds of the upper or Little limestone. They dip west at an angle of 5°, and in that direction the Silurian shale becomes shortly covered by the lower Coal-measures containing the Blue flats and other ironstones. On the north of the town, and east of the Lichfield road, are some large old quarries, in which the lower or Thick limestone was formerly worked, dipping westerly at 10°. This limestone must be continued under the town to the southward, being concealed from view by a very thick capping of

quartzose gravel of the Drift period. Just south of the town it must be cut off by the fault which runs east and west from the south side of "the Moat." This fault is known in the Coal-measures to have a downthrow to the south of 120 feet. Its extension to the east is partly hypothetical, as from Walsall race-course no rock is seen at the surface either southward or eastward for at least a mile and a half.

In tracing the Thick limestone to the north it is seen to bend round and to be cut off by a small fault, a downthrow to the north, near "the Butts." Partly by reason of this downthrow, partly from the rise of the ground, the lower Coal-measures with the Blue flats ironstone here overlap the limestone, and run some distance to the east of its outcrop, till the gradual fall of the ground allows the Silurian shale to come to the surface again.

Near Rushall Castle is another little fault throwing down to the north, but here the Thick limestone again crops to the surface, in consequence of the denudation of the Coal-measures, and has been worked in quarries towards the north-east as far as Linley. In some of the quarries between Rushall Castle and the Halfway House the Coal-measures may be seen on the west side of the excavations resting on the Silurian shale; but the Coal-measure boundary shortly strikes north, while the Silurians strike north-west, in consequence of which at Daw End the Upper or Little limestone comes out from under the Coal-measures, and may be traced by a line of old quarries running in a curved line down towards Ketton's garden. In the canal near here a small supplementary band of limestone is found between the two limestones, and towards the Halfway House a short band of limestone was worked below the Thick limestone. These masses are called "Self lumps;" they are large lenticular masses, in which the calcareous so far prevails over the argillaceous matter as to form good workable limestone.* North and east of Daw End the Silurian rocks are altogether cut off by a great fault, which we may call the Daw End and Linley fault, running north-west and south-east, throwing down to the north-east and bringing in the Coal-measures in that direction.

In this Coal-measure tract was sunk the Trial pit at Aldridge (see Vertical Sections, Sheet 16, No. 4), and another pit between Aldridge Lodge and Hill End. This latter pit, I was informed by Mr. Roberts of the Butts, was 62 yards deep, and that three measures of coal and two of ironstone were passed through, the whole dipping east-south-east at an angle of 25°.

Starting from the Walsall and Daw End limestones, and traversing the ground to the east, we find here and there small openings or cuttings in the shale below them, but we do not get much information till we come to the banks of the new canal running from Longwood Wharf south-south-west by Ginity Graves and the Bell to the Tame Valley canal that runs by Bustleholme Mill and Ray Hall. All down this canal are cuttings in Silurian shale or "bavin," for the most part as nearly horizontal as possible.† East of it, about Hay Head, we get another limestone rising from underneath this shale at an angle of about 10°, running from the fault near Aldridge Lodge down to Daffodilly, where it begins to curve and dip at a high angle, finally ending against the "red rock" near the Skip, its last piece dipping south-west at 35°. East of this, which is locally known as the Barr limestone,

* It must be borne in mind that all the Silurian shale near these limestones is more or less calcareous, and full of calcareous lumps and nodules.

† In cutting this canal a number of fine fossils were discovered, especially heads of Eucalyptocrinus and Echinoencrinus, also many fine and rare brachiopods.

nothing is seen till we come to the "red rock;" but as near Hay Head there is a space of one third of a mile between the two, we ought, if this Barr limestone be truly the representative of the Woolhope limestone, to get the upper part of the Caradoc sandstone series in the intermediate space. The ground is absolutely flat, and rather wet and marshy, and apparently covered by drift clay, so that in the absence of deep excavations this point cannot be settled.

The above passage is left as it stood in the first edition, and it has been already pointed out, p. 109, that subsequent research proved the existence of this sandstone where it was thus anticipated, and showed that it was concealed not only by Drift clay, but by a thin covering of Coal-measures, except in one little ditch or gully at the back of the house called Daffodilly and in a small quarry near Shustoke Lodge. The sandstone, now called Llandovery, rises gently out from under the Wenlock shale, the relations of the beds being precisely the same as at the Colmers and the Long Wood near the north end of the Lower Lickey.

It is possible that the fault before mentioned, which strikes east and west from the Moat, and is supposed to cut off the limestones south of Walsall, is continued to the east, and likewise cuts off the south end of the Barr limestone.

No limestone is known, either by natural outcrop or by sinkings, south of this line. The Silurian shale, however, is seen at intervals, not only in the canal before mentioned but at other points, and was formerly exposed in the cutting of the London and North-western Railway south of Tame bridge. In a horsepond at the Goodwin farmhouse considerable nodules of limestone were got out in the year 1849, rendering probable the near neighbourhood of one of the bands of limestone to this spot. On Delves Green are many old pits in the lower Coal-measures, from which the Blue-flats ironstone had formerly been got, and one of these had been sunk as a trial pit to the depth of 50 yards, chiefly, as appeared from the "spoil" on the pit bank, in Silurian shale. Near the seventh milestone on the Walsall and Birmingham road an outlier of Coal-measures, with sandstone and ironstone, was cut through on the top of the high ground there, making it probable that the whole of this piece of Silurian shale south of the outcrop of the limestones would have been covered by a mask of Coal-measures, had the ground been a little higher and the rocks not worn down by denudation to their present level.

That the Silurian shale continues under the coal-field to the westward of the district now described, dipping gently and equably towards the west, is shown by the following facts:—

On the west side of Friar Park wood a shaft was sunk in 1849, in the first 60 feet of which one or two small coals were found, under which were some ironstones, and below them Silurian shale, in which the sinking was continued to a depth of 150 feet from the surface.*

At Hobbs Hole, a little east of Darlaston, according to the section given at p. 108, from Mr. Smallman's information, there are 292 ft. 6 in. of Coal-measures beneath the Heathen coal, then 60 feet of Limestone shale, followed by the Thin limestone of Walsall, which is there 16½ feet

* This was being done for Lord Dartmouth. I did not see the person who advised the sinking, but the man in charge on the bank was not aware that it was the "limestone shale" or "bavin" they were bringing up, although it was crowded with fossils, and had even nodules of limestone in it; and he told me *they were trying then for coal underneath it.*

thick; and at a depth of 90 feet below that the Thick limestone, which is there 30 feet thick.

At Bentley, south of Pouk Hill, the top of the Silurian shale was about 160 feet deep, and the Thin limestone 373. In the Chillington colliery near Wolverhampton they reached Silurian shale at a depth of 580 feet, and passed through shale and thin bands of limestone for more than 200 feet additional.

In addition to the above places where the Silurian rocks have been reached through the Coal-measures, we have at Deepfields the top of the Silurian shale 680 feet, and the top of the limestone 850 feet deep; at Dudley Port Silurian shale at a depth of 550 feet, the limestone at 620 feet; at the pits at Langley Green, south of Oldbury, a considerable thickness of Silurian shale passed through in a pit not more than 390 feet deep; and the same rock but a little way below the Thick coal at West Bromwich Heath pits.

If we look at these facts, together with that of the protrusion of Silurian rocks at Turner's Hill, the Hayes near the Lye Waste, and the Lickey, we are led irresistibly to the conclusion that a great floor of Silurian rocks stretches immediately under the comparatively thin covering of Coal-measures throughout all the coal-field south of Bloxwich at all events.

The central portion of the coal-field.—The central portion of the coal-field lies in the hollow or basin between the Silurian ridge of the Dudley and Sedgley anticlinal and the Walsall elevation.

If we take Tipton old church, the Moat colliery, and Princes End and that neighbourhood as a centre, the beds, being there deepest, rise thence gently towards the surface in every direction except towards the south. As they approach closely to the Dudley and Sedgley anticlinal they are bent up much more rapidly than elsewhere, the angle of inclination near that outcrop being in some places nearly vertical, and generally as much as 20° or 30°.

The beds rise more gently on the east towards the Walsall Silurian ground, at a mean angle of about 5° perhaps, but still more gently on the north, where the space between the outcrop of the Thick coal and that of the New mine coal is not less than two miles, although the vertical thickness between the two beds does not exceed fifty-six yards (or 170 feet). This gives a mean inclination of only about 1 in 62, or less than 1°. In the same way the Thick coal, when it does take the ground, between Wolverhampton and Bilston, declines so gently into it as never to be more than forty yards deep, and consequently never to be deep enough to take in the Brooch* above it for more than a mile to the southward, till it meets the Lanesfield fault. South of that district the measures in all the middle part of the central portion scarcely vary from a horizontal position. Notwithstanding the nearly horizontal "lie" of the beds over the greater part of the central and south-eastern district, the depth of any measure, as the Thick coal for instance, varies frequently. This variation is produced to a slight extent by the undulations of the surface, but chiefly by the upthrow or downthrow of the faults.

In describing the south-western district it was shown that the two basins into which it is divided were connected at the northern end of the Netherton anticlinal by a trough, which we proposed to call, from

* It is probable that over this space, even if the Thick coal did exceed that depth, that the Brooch would not come in, as the Flying reed coal or upper part of the Thick would come between them.

the name of some old ironworks therein, the Buffery trough. It is just here also, where the two anticlinals of Netherton and Dudley terminate, that there is the closest connexion between the south-west and the central portion of the coal-field. The Thick coal and other beds dip towards the Buffery trough, not only from Netherton, but also all along the south side of Dudley, whence it gradually curves round so as to dip first towards the Rowley Hills and then towards Tipton. The only thing, in fact, which separates the two districts here is the Russell's Hall fault, which is here a simple fracture and downthrow of about 150 feet towards the Buffery. If it were not for this dislocation the central and south-western districts would here become confluent, just as the Cradley and Pensnett basins become confluent.

Now it is from this neighbourhood that the most powerful and dominant fracture strikes into the central district, nearly parallel and almost in a line with the axis of the Netherton anticlinal. This fracture consists of the pair of faults which produce the Dudley Port trough.

At the time when the coal-field was first surveyed these faults were supposed to cease altogether on approaching the basalt of Cawney Hill. In the partial revision of the district, however, which I was able to make in October 1858, there appeared good reason for believing that they did not entirely cease, but that the basalt of Cawney Hill was cut off on the north by the continuation of the north-western fault, and that it was partly separated from that of Tansy Hill by the opposite fault. It is probable, then, that the Dudley Port Trough faults do not entirely cease till they strike the Russell's Hall fault a little to the north-west of Gad's Green reservoir.

Now, it is very remarkable that a small fault proceeds from the northern apex of the Netherton anticlinal obliquely towards the same part of the Russell's Hall fault. There seems, then, to be almost a direct connexion between the Netherton anticlinal and the Dudley Port trough.

If we produce the axis of the Netherton anticlinal it will strike exactly into the centre of the Castle Hill dome-shaped elevation.

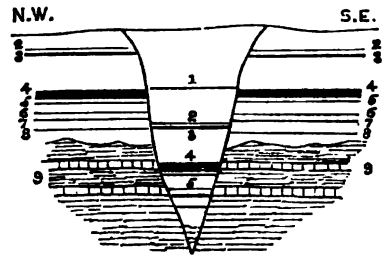
I believe we have in these and similar facts a proof that the forces of elevation and disturbance which were acting on the country to produce the principal features in the lie of the rocks acted along lines running north-north-east and north-north-west, here one force and there another predominating, and producing N.N.E. or N.N.W. fractures or elevations accordingly, with occasional oblique connexions between two parallel and adjacent lines of effect. The two forces seem also to have been sometimes so equally balanced as to have their direction resolved into lines equidistant between them, and therefore running either north or south, as in the Castle Hill and the Wren's Nest, or east and west, as in some of the large faults and dislocations. The north and south lines of course bisected their smaller angle of intersection, the east and west lines the larger angle.

Having dwelt long enough, perhaps, on what is believed to be the law governing the direction of these lines of disturbance, I will now proceed to describe those of the central district a little more in detail.

The Dudley Port Trough faults.—These are two parallel faults starting from near the Free bodies at the north-west corner of the Rowley Hills, and running about north-north-east for about 2 miles up to the Horsley collieries. They are scarcely a quarter of a mile asunder, and each throws down the piece of ground between them to the maximum depth of 130 yards; that is, the piece of Thick coal between them is 130 yards (or 390 feet) deeper than that on either side. (See Fig. 24.)

Fig. 24.

Dudley Port Trough Faults.



Scale 6 in. to 1 mile vertical and horizontal.

1. Upper Sulphur coal.
2. Two-foot coal.
3. Brooch „
4. Thick „
5. Heathen „
6. New mine coal.
7. Fire-clay „
8. Bottom „
9. Silurian shale, with Dudley limestones.

From the maximum of 130 yards, however, the throw of these faults diminishes in each direction to one of much less amount. It has been proved by the workings that each of these faults hades, or slopes downwards, towards the other at an angle of about 70°, they must, therefore, meet at no great distance below the included piece of coal, and as their throw is equal and opposite, they must, where they meet, exactly counterbalance and neutralize each other, and if continued at all, must descend as a mere fissure or crack, without producing any dislocation. It so happens that the included piece of coal is, at Dudley Port, exactly on a level with the Dudley limestone outside the faults, and the workings have been continued from the coal into the limestone. This likewise shows that as regards the mass of the country on each side, these Dudley Port Trough faults (or fault) are no dislocation at all, but only so as regards the piece of ground between them. Nevertheless, it is probable that they mark the line of most intense strain at the period when the elevatory forces were acting on the district. This is a point which for convenience sake we will discuss more fully farther on.

That they had the effect of materially modifying the action of the disturbing force is shown by the fact that to the southward of the Dudley Port Trough all the faults are downthrows to the north, while to the northward of it all the faults are downthrows to the south; in other words, all the faults of the central district form a succession of steps down to the Dudley Port Trough faults.

Faults between Dudley Port Trough and Round's Green.—Starting from Round's Green, between Timmin's Hill and Oldbury, we have 4 faults, with some branches, running about north-east and south-west, and throwing down to the north-west from 90 to nearly 180 feet. The course of these faults is concealed towards the south-west by the trap of the Rowley Hills, while towards the north-east they appear to die out, or at all events have not been traced. The southern fault of the Dudley Port Trough itself dies out towards the north-east, its throw diminishing to 210 feet near Horsley, where it has a small branch throwing down *to the south* 90 feet. Two small faults, with a southern downthrow, likewise start out of it near Roseland farm.

The northern fault of the Dudley Port Trough runs into and coalesces with the Tipton fault near Horsley.

North of the Dudley Port Trough we have 7 principal faults all running nearly east and west, and all having a downthrow to the south. These are (see Horizontal Sections, Sheet 23, No. 1)—

1. *The Tipton and Hilltop fault.*—This has a branch running from Tipton to the south-west, and throwing down 54 feet to the north-west; but its main line at Tipton Green throws down 45 feet to the south, and thence it runs about east-by-north to Hilltop, having a maximum throw of 150 feet to the south near the Eagle furnace, whence it diminishes in amount towards West Bromwich old church to 20 feet and less.

2. *The Bald's Hill fault*, which, just north of Mr. Davis's Crook Hay furnaces near Hateley Heath, has a downthrow to the south of 420 feet. This fault runs east as far as Stone Cross, beyond which its course has never been proved.* To the west of Bald's Hill this fault splits into two branches, the southern of which runs through Gold's Green with a downthrow to the south of 96 feet; the other runs through Hocker Hill, its downthrow diminishing from 120 to 90, and finally to 25 feet, as it runs west.

3. *The Coseley and Wednesbury fault*, which in its central part has a downthrow to the south varying from 150 to 210 feet. To the westward it splits into two, each having a downthrow of 45 and 66 feet respectively, and then diminishing to nothing. On the south side of the town of Wednesbury its throw is 90 or 105 feet, whence it runs towards Crank Hall, and probably dies out.

4. *The Lanesfield fault*, which has a downthrow to the south of 180 or 210 feet, near Hallfield, diminishing in each direction, and finally dying out. Towards the west this fault splits into two well marked branches, which have a throw at first of 105 and 66 feet respectively, the southern branch diminishing very regularly from 105 to 30 and 20 feet, the northern being cut off by one of those faults mentioned before as being very numerous and complicated in the corner of the coal-field north of the Sedgley ridge, and marking the prolongation of the disturbing power which produced the anticlinal.

5. *The King's Hill fault* is a very slight one, having a throw of not more than 20 to 25 feet to the south.

6. *The Darlaston fault* has just east of Darlaston a downthrow to the south of 66 feet. It is not known east of that, but it may possibly run along the north side of Delve's Green, where the Coal-measures stretch eastwards over the Silurian shale. To the west it splits half a mile from Darlaston, its branches diminishing to 27 and 9 feet respectively, and shortly disappearing.

7. *The Moat fault* mentioned before as running south of Walsall. It has a downthrow to the south of 120 feet just south of the Moat, but nothing more is known respecting it.

Mr. George, of Bentley, has lately pointed out to me another fault a little south of the Moat fault, running parallel to it, and likewise having a downthrow to the south.

Several other small faults may also be seen marked on the map, not worth a more detailed description.

Outcrop of the Thick coal.—It will be worth while briefly to follow the outcrop of the Thick coal over the district thus broken by faults.

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* The country here is very much covered by drift. Mr. Yardley, of Tipton Moat, informed me that at Mr. Bagnall's Moorland colliery, near Hateley Heath, it was at one pit 165 feet to the top of the Thick coal, over which there were only 51 feet of "rock binds," &c. for a roof; all the rest, or 114 feet, being drift sand and gravel.

Its outcrop along the eastern flank of the Sedgley and Dudley anticlinal ridge has already been described (p. 149), and it has been shown how it is dislocated by the western branches of the Lanesfield fault, and that a detached piece was thrown in towards the Wolverhampton furnaces in consequence of other faults having a downthrow in that direction aided by a rude sort of anticlinal arch that occurs about Parkfield.

The outcrop then runs along the western side of Ettingshall Lane for some distance, and then turns across it and across the Wolverhampton and Bilston round toward Batchcroft and Priestfield. A small east-and-west fault, with a downthrow to the north, throws in another little detached piece towards Monmore Green. The outcrop runs thence very steadily about east by south to Darlaston, where it is broken by the Darlaston fault and partly deflected to the north by the rise of ground. Thence the outcrop runs south-east till it is broken and thrown forward to the east by the King's Hill fault, whence it runs south to the Lanesfield fault, which again throws it forward to the east. Thence it begins to run nearly south-west into the northern part of Wednesbury, when it is cut through and thrown nearly half a mile to the east by the Coseley and Wednesbury fault. South of that fault it runs about south-south-west, and is deflected by the valley of the Wednesbury brook, south of which it meets the Bald's Hill fault. The outcrop is then thrown to the east more than a mile to Stone Cross, partly by the downthrow of the Bald's Hill fault, partly by the rise of ground, and partly perhaps by a flattening of the dip of the measures. From Stone Cross it strikes about south-south-west till cut by the extremity of the Tipton fault north-west of West Bromwich old church. This fault, however, is here very slight, so that the outcrop seems scarcely affected, but continues as far as the Hall End colliery. In this it meets with a fault running about north-east by north, which has a downthrow to the south-east. This would throw the outcrop still farther to the eastward, in which direction, however, everything is so covered by drift that its outcrop is not known. There then appears to be another fault ranging about north-east by east, having likewise a southerly downthrow, bringing in the red rock of the Permian formation, under which the Thick coal continues for some distance at a depth of 600 or 700 feet till it ends, either in a rock fault, an outcrop of the beds into the Permian rock, or against an upthrow fault. It is not improbable that the Thick coal terminates for a time, if not altogether, towards the east under the Permian rocks, in one or all three, of the methods alluded to above. From the south side of the Tipton fault, about two-thirds of a mile west of West Bromwich old church, a fault strikes off to the southward with a downthrow to the east, and runs thence through Oldbury to the Quinton. This will be described presently under the head of the Boundary faults.

The south-eastern part of the coal-field.—Between it and the Rowley Hills is the south-eastern portion of the district, in which the beds appear to lie very regularly and horizontally, although the Thick and other coals are greatly injured by the quantity of sandstone interstratified with them, as before described. Such as they are, however, these beds appear to have been very little disturbed by fractures and dislocations, the debased representative of the Thick coal passing under the Rowley basalt on the one side and striking against the Boundary fault on the other at a depth of 400 or 500 feet, often thinning from 30 feet to 3 feet in all directions, and being frequently not worth the trouble of getting. South of Causeway Green and Cakemoor little or nothing

is known either of the constitution or the "lie" of the Coal-measures, but they are believed to dip gently to the southward until they pass beneath the red rock found above the Lappal tunnel. These red rocks may be seen occasionally thereabouts to dip south at an angle of 5° to the south.

From the neighbourhood of the Lappal tunnel, however, it will be seen, by reference to the map, that a curious little narrow strip of Coal-measures runs out two miles to the east, as far as the Stone House near Harborne. The existence of Coal-measures at the surface along this strip is shown partly by the rubbish got out of the shafts of the tunnel near Wilderness Farm, but principally by a pit sunk by Mr. Flavel, between the Stone House and Bog Meadow Coppice. From this pit, which was 80 yards deep, nothing but Coal-measure shales and "binds," with small ironstone nodules, was extracted. The measures dipped north at about 10°, and they may possibly have dipped regularly under the Permian and New red sandstone rocks which stretch from Harborne to the Quinton, though it is much more likely that the boundary between them is a fault. On the south side of the ridge, at all events, the boundary must certainly be a fault, as near the Stone House brick red sandstone may be seen dipping south at 10°; flattening to 5° at the quarry beyond Weoley Castle.

The northern portion of the coal-field.—The northern portion of the coal-field is the part between the Great Bentley fault and Brereton. None of the faults we have hitherto been examining, with the exception perhaps of the Russell's Hall fault, exercise any marked influence on any large portion of the country. They merely traverse the beds for a certain small distance, and alter their levels over a certain limited space, the amount of the alteration soon diminishing to nothing. If either of these faults did not exist, there would rarely be any material change in the nature or character of the rocks of the locality.

With the Great Bentley fault, however, the case is different.

We have seen that between Wolverhampton and Walsall the Coal-measures crop gradually, but steadily, to the north, so that, first the Thick coal, then the Heathen, then the New mine, rise to the surface of the ground and end towards the north. The Fire-clay and Bottom coals are but a few yards deep about Bentley Lodge and Deepmore Coppice; and it is clear that if this gradual rise of the measures to the north had continued uninterruptedly for a comparatively short distance further, the very base of the Coal-measures would have come up to the surface of the ground, and the Silurian shales and limestones would then have cropped out beyond, spreading north perhaps for many miles. Cannock Chase would in that case have been a Silurian instead of a Coal-measure country.

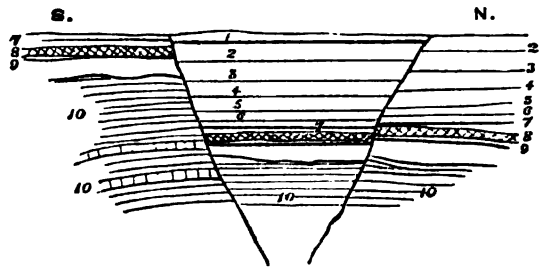
The great dislocation of the Bentley fault,* however, throwing down to the north to the amount of 120 yards (360 feet), brings in the Coal-measures even up to the base of the Thick coal, and that formation then spreads to the north, forming the surface of the ground, till it is concealed under the New red sandstone.

About a quarter of a mile north of the Great Bentley fault another runs parallel to it, throwing down to the south 25 yards, and to that extent forming a trough, or neutralizing the effect of the northern downthrow; still, however, leaving nearly 100 yards of downthrow to benefit the country on the northern side of the trough. (See Fig. 25.)

* Mr. James George, of Bentley, is my authority for all the faults of that neighbourhood, he having placed all mining plans, &c., at my disposal, and frequently communicated to me all the information he possessed.

Fig. 25.

Great Bentley Fault.



Scale 6 in. to 1 mile, vertical and horizontal.

1. Old man's coal.
2. Bentley Hey „
3. Heathen „
4. Sulphur „
5. Yard „
6. Bass „
7. Fire-clay coal.
8. Green-rock trap.
9. Bottom coal.
10. Silurian shale, with Dudley and Walsall limestones.

In the trough between these two faults, on the south side of Bentley Heath, they get a nine-foot coal, called the Old Man's coal, which crops out shortly in each direction, as it is never more than 5 or 6 yards deep. The Bentley Hey coal, 5 feet thick, is 50 feet under this; and the Heathen coal, 50 feet under the Bentley Hey. We have already seen that the Old Man's and the Bentley Hey coals must, if even only on account of their relation to the Heathen coal, be the bottom beds of the Thick coal separated into two.

The eastern outcrop of the Old Man's coal in the Bentley Trough is just north of the Bentley furnaces, the Bentley Hey coal cropping west of the canal near Birch Hills, and the Heathen and lower coals cropping out successively to the east as we follow the trough towards Ryecroft.

The Great Bentley fault appears to branch towards the east in the manner represented in the map, its branches running up to Rushall and dislocating the measures there, as before mentioned in the description of the Walsall Silurian district. To the northward of the Bentley Trough, the Bentley Hey coal crops in the bed of the brook (which afterwards forms the little river Tame), north of the Bentley Heath furnaces, and the Heathen coal crops a little to the eastward of that.

These two outcrops run off northward with an undulating line in consequence of slight undulations in the surface and variations in the dip of the beds, for about a mile, the general dip being to the west at an angle of 3° or thereabouts. Several east and west faults are then met with, the most important of which runs north of the New Invention and south of Bloxwich. This in the centre of its course has a downthrow to the north of 195 feet (65 yards) diminishing, apparently, in each direction. Two little faults, with insignificant downthrows to the south, run between this and Sneyd's Pool reservoir, while one to the south of it running through Herbert's Coppice has a downthrow to the south of 45 feet (15 yards) with another very small one to the south of it, having a small downthrow to the north. After being dislocated backwards and forwards by these faults the Bentley Hey coal crops at the south side of Sneyd's Pool, beyond which nothing is known of the outcrop, although the coal itself is met with in the deep sinkings

at Essington and Wyrley *below* the coals worked there, as also in the deeper pits of the Brown Hills district, *above* all the coals that are usually gotten in that neighbourhood.

The Heathen coal crop is known, after traversing the New Invention fault, in the south-western part of Bloxwich, beyond which it has not been traced, though the coal itself is also said to occur in the deep pits of the Brown Hills district at the proper distance below the Bentley Hey coal.

The outcrops of these coals ought eventually to be discovered along the line of country running by Little Bloxwich, Fishley, and Little Wyrley, or Wyrley Common.

Let us return now to the Bentley and Birch Hills district. It appears that the northern fault of the Bentley Trough likewise splits up towards the east, the branches running off to the east-north-east, and dislocating the lower Coal-measures and their outcrops in the way represented in the map. Mr. Beckett, of Wolverhampton, is my authority for the three faults running about north-east and south-west from Birch Hills Hall to Harden, and through Goscott Lodge and Coal Pool, which are delineated on the map. The latter appears to be the same as the northern branch of the northern Bentley Trough fault.

It will be recollected that the New mine coal is here already separated into two, known as the Yard and the Bass coal, that the Fire-clay coal changes its name, and further north is called the Cinder coal, but that the Bottom coal continues to carry a thickness of 12 feet, (whence about Goscott it is sometimes called the Thick coal,) up to the southern corner of Pelsall Heath.

This Bottom coal was admirably exposed in October 1858, in a long open work east of Goscott Lodge, belonging to Mr. Brewer. The coal here ran north till it was cut off by a fault having a downthrow of some ten yards to the north, which is believed to be the extension of one of the faults already quoted as communicated by Mr. Beckett.

From all the accounts I could collect it appears certain that the faults are even still more numerous in this district than they are represented to be in the map, their complications being in some places so great as not to be unravelled without maps on a much larger scale, and hardly perhaps even then. The lie and position, then, of the faults and of the broken outcrops of coal about Harden and Goscott, and thence up to Pelsall, which are given in the map, are to be taken as to a certain extent hypothetical. They represent the simplest and most consistent and logical explanation that could be arrived at, of a number of isolated facts, which could not be represented at all without some partly hypothetical connexion.

About Pelsall Heath I am indebted to Mr. Gilpin, of Church Bridge, and his ground bailiffs, — Russell and John Brooks, of Pelsall, for much recent information.

It was from their accounts, confirmed by that of Mr. Brewer and others, that I learnt the precise spot where the Bottom coal begins to separate into two, namely, just at the old public house known as the Red Cow, at the south end of Pelsall Heath.

I must also quote Mr. Gilpin as my authority for the fault running north-east and south-west to the northward of Pelsall Heath, with a small upthrow to the north-west, as shown by the Yard coal just coming in at the corner of Pelsall Heath on the south side of it, while none was found immediately north of it, though it existed under the hamlet marked Pelsall on the map. The Deep coal (or lower part of the Bottom coa was said to crop in Rail's coppice, and was only three

yards deep in a field immediately south of the Ryder's Hayes colliery. As, however, the Deep coal is got in the Ryder's Hayes pit at a depth of forty yards, it is clear there must be a fault with an upthrow to the south of at least twenty yards just south of the Ryder's Hayes colliery.

North of this there are several east and west faults, all having a downthrow to the north, which were pointed out to me by Mr. Gilpin, and also by John Birch, of the Brown Hills. One with a downthrow to the north of twenty yards runs just south of "The Moat," while north of that there is one with a downthrow of three yards in the same direction. Other small faults were spoken of as running parallel to these, and eventually another downthrow of twenty yards to the north, a little south of the canal bridge, now generally known as the High Bridge.

High Bridge Trough.—A little north of the High Bridge there runs, according to the same authorities, a fault about west by north and east by south, having an upthrow to the north of eighteen yards. There is thus produced a trough (which we will call the High Bridge Trough), and in this the Deep coal is worked close to the canal just south of the bridge, at a depth of 100 yards. As we cross these faults from Rail's coppice by Ryder's Hayes to the High Bridge Trough the outcrop of the coals will necessarily be thrown to the east by each downthrow, so that in the High Bridge Trough the Yard coal, and perhaps the Bass coal, will alone be able to crop to the surface before the beds are cut off by the Clayhanger and Daw End fault, which runs north and south from the Brown Hills, and will be spoken of hereafter.

North of the High Bridge Trough there are several other east and west faults, as pointed out to me by John Birch of the Brown Hills, having upcasts to the north, and therefore throwing the crops of the coals to the west, until we arrive at a curved fault running from Wyrley Hays by the canal south of Birch's coppice, which has been inserted from the mining plans put at the disposal of the Norton Manor Commissioners, of which we owe the inspection to the kindness of Mr. Beckett. North of this fault the crops of the Yard, Bass, Cinder, and Shallow coals range, apparently unbroken, through Birches coppice to the north till we reach the Rising Sun trough, the Deep coal cropping into or against the Clayhanger and Daw End fault, as formerly described to me by W. Arblaster and confirmed by John Birch. The two little east and west faults near Fishly and the Woodhouse are inserted on John Birch's authority, while those running north-east and south-west between Wyrley Common and Birch's coppice are taken from the mining plans just now alluded to.

Rising Sun Trough.—Approaching Watling Street between "The Rising Sun" and "The Machine" we meet with another twenty-yard trough, as described to me on the ground by John Birch. This will again throw the outcrop of the Yard coal very close to the Clayhanger fault, and thus place the beds in the same relative position as they have in the High Bridge trough. It is in this Rising Sun trough that the deep pit was sunk by Mr. Harrison which passed through the Sulphur, Heathen, and Bentley Hey coals, facts which enable us to connect, with much more assurance than before, the Brown Hills coals with those of Wyrley.

North of the Rising Sun Trough the faults, with their downthrows, are inserted from the authority of the mining plans used by the Norton Manor Commissioners, and the outcrops of the coals have been drawn in accordance with the indications given by those faults and the fact of the occurrence of the different coals in the different shafts, and their depths from the surface.

The lie and position of the beds hereabouts have already been partly described (pp. 72, 87), as it was necessary to do so in order to arrive at any conclusion as to their structure and constitution. It was shown that however broken and dislocated the beds might be by the different faults that traversed thom, they nevertheless preserved all the way from Bentley and the Birch Hills, by Pelsall up to Watling Street, a steady dip to the west of about 3° on an average. North of Watling Street, however, they begin to curve round so as to dip first west-north-west and then north-west, and even north-north-west, at the same low angle of inclination.

Mr. Bills, the ground bailiff of the Cannock Chase colliery, informed me, in October 1858, that they had driven gate-roads in the coals to the north-westward of their present shafts for a distance of 500 yards without meeting with any appearance of a fault or anything that would seem to interrupt their working. The pits then in use were just south of the place, where "*Little*" of "Little Longfield" is engraved on the map, so that they must have now driven under Norton Bog. He informed me that the beds dipped very slightly towards the north-north-west, being sometimes absolutely horizontal over a considerable space. He confirmed the "lie and position" of the faults drawn in the map about Norton and Norton reservoir.

I was formerly informed by a collier working at Pelsall that on following the Shallow coal from Pelsall wood towards Fishley it was found to get gradually thinner, and eventually to die out altogether. I was also informed by Jesse Potts, of Wyrley, and others in that neighbourhood, that the Wyrley Eight-foot or Bottom coal cropped a little east of the Bloxwich road about Jacob's Hall.

All the measures of the Wyrley district have a gentle westerly dip, so that the highest beds are only to be found in the most westerly shafts, while they crop out successively towards the east. The most westerly shaft is that of the Waterloo colliery, near Longhouse, where they got, at a depth of 150 feet and a height of 76 feet above the Old Robins coal, a group of beds having 7 feet 4 inches of coal separated by partings of two or three feet, with another little coal 10 feet above them. The beds soon crop out to the east, and are not known in any other of the Wyrley pits. At Essington colliery, however, they get a similar group of beds at a height of 61½ feet above the Old Robins coal, having a total thickness of 7 feet 4 inches of coal with one little parting of 2 inches, and another small coal above them. These two groups of beds are evidently the same, and they are probably the coal which has been found in the wells and in the foundations of the houses at Wyrley bank, just striking the high ground there.

Mr. Gilpin has lately informed me that the whole of the Wyrley district is chopped up by faults of greater or less magnitude, and so numerous that he found it quite impossible to trace them on the one-inch map. The three north-north-east faults, formerly marked on the map, are correct so far as they go, one running through Great Wyrley with a downthrow to the west, and two others running a little east of Wyrley bank with downthrows to the east of twelve and sixteen yards respectively. Of these two the most eastern splits up, towards the south, into several branches, and terminates. The other one, however, continues with an increasing throw towards the south, and turns off towards the east-south-east with a downthrow northwards of thirty-two yards. It may possibly run off in that direction till it is connected with the northern downthrows on the south side of the High Bridge Trough. A little south of Wyrley bank this fault is crossed by another running nearly east and west, with a downthrow to the south of twenty

yards. Mr. Gilpin also informed me that among the numerous faults about Church bridge there was always found six or eight yards of red clay *in the fault;* the fault having that width, and being filled with red clay.

In consequence of these numerous faults it is impossible to lay down upon the maps the outcrops of the coals in any intelligible manner. The dotted lines drawn on the map represent the general approximate boundary of the area within which the respective coals may be found, rather than their actual outcrop. Even where they are not broken by actual faults they appear as they approach the surface to flatten and undulate, which undulation of the beds, combined with that of the surface, causes each bed to crop in and out several times successively before its final disappearance.

Added to all these difficulties is that caused by the occurrence of vast quantities of drift, as much as 60 feet of running sand having been sometimes found, as well as clay and boulders. The boulders are many of them granite and often of very large size.

The most southerly of the shafts that can be said to belong to the Wyrley district are two near the Warstone. One of these, situated just about where the "o" of "Warstone" is engraved on the map, has the Wyrley Bottom or Eight-foot coal at a depth of 180 feet (60 yards), while in another pit, about 200 yards to the eastward of it, that coal is only 105 feet (35 yards) deep. The Cannel coal accordingly must crop between these two shafts. At the coal-pits now at work immediately to the east of the Old Mitre, the Cannel coal was only 10 yards deep. It must, therefore, crop a very little way to the eastward of these shafts.

At Mr. Mills's new colliery to the westward of the Old Mitre (just where the "T" of "The" is engraved in the map) the Cannel coal is 396 feet (132 yards) deep, proving, with the gentle dip of the measures, that there must be a fault with a large downthrow to the west, between these two places. The amount of this downthrow is stated at 65 yards (195 feet). The dip of the beds on the downside of this fault is about west-north-west, in which direction they will pass obliquely under the red clays, &c. of Essington Wood. By means of these red clays and the New and Old coal workings on the opposite side of the lane, the fault can be traced by Holly Bank and the Warstone up to Cheslyn Hey, where it probably runs into the western boundary fault.

Its course is about north by east, and there is another little fault parallel to it, some distance east of the Old Mitre, with a downthrow to the west of 15 feet (5 yards).*

South of the Essington pits little or nothing is known either of the constitution of the Coal-measures or the "lie and position" of the beds till we reach the greenstone of Wednesfield on the one side, and the Bentley and Bloxwich works on the other.

An old shaft sunk a little east of the New Invention seems to have gone through nothing but Greenstone, of which large blocks may still be found under the soil full of veins of some zeolitic mineral. Other sinkings are reported to have been made formerly to the north of this, between Essington and Pelsall in the district called Essington Wood, and the measures were said to be all destroyed by white rock and green rock trap. White rock trap is to be seen in the cutting of the railway near Landywood, which is the farthest point north at which it is known to exist.

It is also found, as before mentioned, south of Bloxwich about Birch Hills and thence to Pouk Hill, burrowing in the lower measures, and dislocated with them by the various faults that traverse them.

* We are indebted to Mr. Beckett for much of the above information, he having gained it from Messrs. Mills, and from Mr. Smallman, the ground bailiff, of Wednesbury, as also from Mr. Chekley, of Spring Hill, near Bloxwich.

If now we go north of the district already described towards Cannock Chase, we meet, first of all, with the old outcrop of coal north of Norton church which has been already spoken of as probably either the Bentley Hey or the Wyrley Eight-foot coal. This coal strikes north-east and south-west, with a dip to the north-west.

Farther north still, is the old outcrop running from near Heathy Hays to Cooper's Lodge, the old pits at Cannock Mill, and the old and present sinkings at Hednesford. At all these places the dip is said to be towards the north-west.

In the old workings on the north-west side of Hednesford Pool a number of step-like faults were said to have been met with, throwing the beds up and down in various directions, but principally down to the west to the amount of a few yards at a time.

From Norton and Hednesford the beds appear to strike regularly north-east towards Beaudesert and Brereton.

The outcrop of a coal may be seen in the valley of the brook south of Castle Hill, while another outcrop may be seen in a little gulley on the north side of it in Beaudesert Old Park. Old coal-pits are scattered all over this old park, all of which were said to go down to the same coal, and none to have been more than about 30 yards deep.

This coal must accordingly lie as nearly as possible in a horizontal position. Beyond it the beds seem to have changed their dip to the south-east.

At the Brereton collieries the general dip of the beds is south-east, at an angle of about 3° to 5°. There are 15 coals, some of which are very thin, in a total section of about 620 feet (see Vertical Section, Sheet 16, No. 1).

On the eastern side of the workings they drove out from the Fifteenth coal, which is there about 460 feet deep, towards the eastward, and came into a hard gravel rock. This was, doubtless, one of the conglomerates of the New red sandstone,* and the fault bringing it down to this position was part of the eastern boundary fault of the coal-field. This fault runs just under Mr. Poole's office. South and south-west of this point several shafts have been sunk through some of the beds of the New red sandstone down to the coals. These New red sandstone beds consist of red and white sandstone, and gravels, with some red marls; they appear to be quite horizontal. In the lower grounds they are about 70 or 80 feet thick, but measuring from the top of the inclined plane of the Hayes colliery, belonging to the Marquis of Anglesey, they are nearly 200 feet thick. The coals rise regularly from Brereton Hayes wood, where the Coal-measures are at the surface, at an angle of 3°, so that under the New red sandstone they crop up into the base of that formation. In the pit below the foot of that inclined plane, for instance, they had—

	FT.	IN.	
1. Gravel	80	0	New red sandstone.
2. Red and yellow marl	6	0	
3. Rock	5	0	
4. Clod and batt	5	6	
5. First coal	4	6	
6. Intermediate, with Three coals	125	0	
7. Fifth coal	4	0	
	230	0	

* Mr. Vernon Poole, Lord Talbot's agent, gave me this and all other information as to the mines under his charge.

While at the top of the incline they got—

	FT.	IN.	
1. Gravel - - -	120	0	New red sandstone,
2. White sand rock - -	69	0	189 feet.
3. Clod - - -	110	6	
4. Fifth coal - - -	4	0	
	303	6	

A little beyond the top of the incline is a fault running north-east and south-west, throwing down to the north-west 25 yards.

About ¼ of a mile north-west of this another pit has been sunk, in which they got—

	FT.	IN.	
Gravel - - -	186	0	New red sandstone,
Ditto and White sand rock -	129	0	315 feet.

when they came down into the Coal-measures, and were stopped by water; they then bored into a coal just below which was supposed to be the Fifth coal.* Farther on, nearly a mile to the north-north-west, in a field of the Birches farm belonging to Lord Lichfield, just south of the Rolling Mill Pool, a boring was made some years ago, the account of which was given me by Mr. George. In this boring they passed down through 418 feet of alternations of "red rock," "gravel," "marl partings," &c. Below that they came into "black marl," and then had alternations of "black marl," "red marl," "white rock," "ironstone," and "red rock," and marls to the total depth from the surface of 612 feet. At a depth of 545 feet they are said to have found a coal 13 inches thick, with a foot of fire-clay below it, and alternations of "red rock," "red marl," and "blue binds" below that. What these lower rocks were, whether they were true Coal-measures, or whether they were Permian rocks, which, as we have seen, do contain fire-clay and coals, it is exceedingly difficult to say. The mention of ironstone would seem to give it in favour of their being Coal-measures, but there are ferruginous concretions in some of the Permian rocks which in the auger of the boring rods might seem to have been derived from true Coal-measure ironstones.

From the Brereton district, where, as we see, the Coal-measures are partly covered by some beds of the New red sandstone formation, resting unconformably on the edges of the coals, a range of hills runs south-west, ending in the bold ridge of the Hednesford Hills. All the high ground of this range is composed of beds of soft red and white sandstone and gravel, which apparently belong to the New red sandstone formation. Along their south-east margin, old coal-pits are abundant, and wherever a little valley cuts into them, the old coal-pits run down it for a short distance. Old coal-pits, with abundance of coal shale on their banks, are found on both sides of the Hednesford Hills, and everything goes to make it probable that at this northern side of the coal-field the

* I was indebted to the late Mr. Figgins for information as to all the collieries under his care.

No farther operations seem to have been carried on at this boring on Flaxley Common, and I think it exceedingly doubtful whether they reached Coal-measures at all. Any such information derived from boring is always of the most uncertain and untrustworthy character.—(Additional note in 1858).

boundary is formed by an unconformable overlap of the New red sandstone resting horizontally, or nearly so, on the slightly inclined edges of the Coal-measures. Near Littleworth there are some clay pits, in which blue bricks are made from some beds that appear to be the upper red clays of the Coal-measures, like those at Rumour Hill, at Essington Wood, and at Walsall Wood. If this be so, and our identification of these measures be correct, it will follow that all the Essington and Wyrley Coal-measures will there be found below, and probably, therefore, all their coals and ironstones.

The reader will recollect that the southern margin of the coal-field was formed by the Permian rocks resting on the upper Coal-measures in *apparent* conformity, both being horizontal, or dipping at the same imperceptible angle to the south. Both the north and south boundaries of the coal-field, then, are formed by the simple denudation and removal of the superior rocks, and the consequent appearance of the lower ones at the surface of the ground; the only difference in the two cases being that in the one the superior rocks were in apparent conformity to the inferior, while in the other they were distinctly and obviously unconformable.

CHAPTER XII.

The Boundary Faults and the Rocks surrounding the Coal-Field.

We will now examine the east and west boundaries of the coal-field. One difference between these and the north and south boundaries will strike us at the first glance of the map. Instead of being irregularly and deeply indented, and conforming to the natural surface of the ground, advancing or receding with its hills and valleys, the east and west boundaries are regular and equable, preserving a certain mean course with great persistency, and when curving, doing so gradually, and with a wide and steady sweep, forming a curve of large radius. The north and south boundaries are like an indented coast line, the east and west are like artificial roads, going nearly straight across the country, with but little respect to the variations in its surface. These boundaries, indeed, are not the result of mere denudation alone (or of that action by which the present configuration of the surface has been produced), but of denudation combined with great longitudinal faults, which at the very period of their formation produced a sudden change in the ground along their line, so that no subsequent lowering of the level of the ground, though it may slightly shift the position, can much alter the character of that change. This difference in the nature of the two boundaries has a very important practical bearing. When the boundary of a coal-field has been formed by

simple denudation, without any faults in the neighbourhood, we can follow the beds of coal under the other rock without much regarding it; it is simply an additional matter of so much thickness interposed between the surface and the bed, and if the dip of of the two rocks be known, and the surface be levelled, the depth of the coal can be calculated with the greatest facility. When, however, the boundary of a coal-field is caused by a fault, the mere dip of the rocks is no longer a trustworthy guide to us. The "throw" of the fault, as also the angle of its inclination, or "hade," is *à priori* unknown to us; we have therefore commonly no means of judging how far the coal-bed is depressed on the other side of the fault below its level on this, and if we knew that, we should perhaps have no means of ascertaining how far the fault "haded," "overhung," or "inclined;" or, in other words, how far we ought to go beyond the broken end of coal on this side of the fault before we felt sure that we were standing over the other end of the bed on the other side of the fault.

The determination of the nature and character of the boundary faults of the coal-fields, therefore, is one of the most important practical points which it is the province and the duty of a Geological survey to solve, since it is one of those least within the power of an individual observer, examining only small and isolated localities, to understand and explain.

I was at one time strongly inclined to entertain the supposition that the boundary faults of the Midland coal-fields were of the nature of cliffs rather than of fractures. It appeared from certain circumstances rather probable that the previously existing Coal-measures had been almost entirely destroyed and washed away, except in the parts where they are now seen at the surface; that in those parts they had been left as islands, round which the beds of the Permian and New red sandstone had been deposited, abutting against the old Coal-measure cliffs, their beds taking the place of those that had been swept away. Facts such as those we have seen in the Brereton district, where the coal cropped up into the New red sandstone, without the intervention of any fault, lent strength to this hypothesis. Soon after the commencement of the survey of the South Staffordshire Coal-field, however, my belief in this hypothesis was greatly shaken, and it was finally abandoned, so far as the supposition of any long line of lofty cliff was concerned, having a more or less nearly perpendicular face, with several hundred feet of New red sandstone deposited against it. The very form of the east and west boundary faults of this coal-field was against this supposition. Direct evidence against it, as to the West Bromwich district at all events, was soon obtained, and all doubt was finally set at rest when the boundary between the New red sandstone and Permian formations was surveyed. For it then appeared that sometimes a broad tract of Permian rock lay next outside the boundary fault, sometimes none at all. If, therefore, the gap caused by the supposed denudation of the Coal-measures had been first of all filled up by Permian, it would follow that that formation itself

had subsequently suffered an almost equal amount of destruction, and another great cliff formed; and that in some places the whole of the Permian formation had been utterly removed, and the old Coal-measure cliff re-exposed, only to be again concealed and the second gap filled up by subsequently-formed beds of New red sandstone. Such a recurrence of so singular a phænomenon was too much for the wildest hypothesis to affirm; and we shall, I think, see reason to conclude that the east and west boundaries of the coal-field are not only genuine faults, clean-cut fractures, but that they were produced late in the New red sandstone period, if not subsequently to it altogether.

The practical bearing of this discussion will be at once seen, if we reflect that on the first supposition of the boundaries being cliffs, a very large part of the Coal-measures, with their accompanying wealth of coal and iron, must have been removed from the spaces between our present coal-fields; if, on the other hand, the boundaries are faults, we have still all or the greater part of the Coal-measures concealed and untouched under the New red sandstone of the great central plain of England.

We will now examine a little in detail these two boundary faults, commencing with the eastern one near its southern extremity on the Birmingham and Halesowen road.

The Eastern Boundary fault.—At Perry Hill the angular trappean breccia of the Permian rocks is seen in the cutting of the road, the Red rock extending up to the turnpike. Near the Hagge, Round Hill, and "Barn," yellow Coal-measure sandstone may be seen. Just where "ra" of "Brand Hall" is in the map is an old quarry in the calcareous conglomerate, described before as occurring in the Permian rocks. This band of calcareous conglomerate can be traced thence to Barnford Hill, where it is much farther from the fault than it was at Brand Hall. This looks as if the fault increased in amount as it ran south, concealing more and more of the Permian rocks, and thus bringing this conglomerate bed nearer and nearer to it.

About 350 yards south-west of Langley mill there is an old pit only 130 yards (390 feet) deep, which, from the quantity of Silurian shale full of fossils on the bank, must have had almost the whole of its lower half altogether in that formation.* This is very near the boundary fault, but how the Silurian shale comes to be so near to the surface as even 100 yards is not easy to explain. From some old mining plans of this locality lent to me by Mr. S. H. Blackwell there appeared to have been here a curious complication of faults, the clue to which I did not succeed in unravelling. A little north of this, in Mr. Chance's pits, the Thick coal thinned out to 7 feet as it approached the fault. Red rock can be seen at the surface very near the line of the fault as it is drawn on the map. It is probable, then, that there is here a complication similar to that described before in Lord Dartmouth's Heath pits at West Bromwich.†

* It is a curious instance of the frequent want of the commonest knowledge in this district, that an intelligent man who acted often as a "ground bailiff" in the neighbourhood, his father and brother being both of that profession, was yet not aware that it was impossible to find coal beneath shale containing Silurian fossils.

† A dotted line was drawn on the map to call attention to the probable connexion between these two places. This connexion subsequent workings near Spon Lane have proved not to exist on the Thick coal level all the way, at all events not to run along the exact line drawn in the map, though it may run a little farther east of it.

North of Oldbury the fault is very well traced. At the Flash we have the Thick coal 60 yards (180 feet) deep on one side, and 212 yards (636 feet) on the other, giving a downthrow of 152 yards (456 feet); but the amount of "red rock" sunk through was not known. At Mr. Bennett's pits at Ireland Green the Thick coal is 170 yards (510 feet) deep, while on the other side of the fault, near "the Oaks," it is 288 yards (864 feet), giving a downthrow of 118 yards (354 feet). At the Terrace pits at Christchurch the Thick coal is 252 yards (756 feet) deep, and it was said to be only 45 yards (135 feet) to the bottom of the "red rock," the downthrow of the fault being 88 yards (264 feet). This fault continues to hold its course to the northward for a mile beyond this point, having still a downthrow to the east of 60 or 80 yards (110 to 240 feet), till it appears to be cut off by the Tipton and Hilltop fault. North of the Cross Guns Inn, however, in the Wolverhampton and Birmingham road, it is no longer the boundary of the coal-field even at the surface, as there is no red rock on either side of it. At a new pit sunk about the foot of the "L" of "Lyndon" in the Ordnance map they sank below the Broach coal without meeting with any red rock. From the depth of the Broach here it will be about 200 yards (600 feet) to the Thick coal. About one-third of a mile to the south of this spot is the Lewisham pit, at which the Thick coal is 290 yards (870 feet) deep, and there is said to be 105 yards (315 feet) of red rock above the Coal-measures. It is doubtful whether there be a fault, downcast to the south, between these two points, or whether the lower level of the Thick coal at the Lewisham pits is due merely to the southerly dip of those from Lyndon. A dip of 10° would be sufficient for the purpose. If there be no fault, the Permian red rock must come in either by simple capping of the Coal-measures, or it may have been originally deposited in a sudden hollow of erosion existing formerly in the Coal-measures of that locality. East of Lyndon and north of the "red rock" the Thick coal is said to end at a depth of 200 yards (600 feet) against a mass of "rock and rig." This is probably an extension of the "rock fault" found both in the "Heath" and "Lewisham" pits as before described.

From this point we have to traverse a district of very great obscurity for two or three miles. A ridge of drift gravel runs from Sandwell park by West Bromwich old church to Charleymount. This drift is in some places 120 feet thick, and effectually screens all the rocks below from observation. At a small public house between Bird End and the Wigmoor station gas escapes from the ground in such quantity that it is used to light the house and the neighbouring cottages. It is almost certain, then, that there are Coal-measures under this spot, though they can only contain the lowest beds of coal. In the cutting of the railway to the north-east of Crank Hall farm Silurian shale full of fossils was found lying horizontally.

In the road going from Wigmoor station to Newtown, red rock may be observed apparently horizontal. "Red rock" spreads from this point over all the country to the north and east. Trusting to these facts, a dotted or supposed fault has been drawn from the Cross Guns to Sunday Bridge. From this point towards the north we have on one side of a certain line running about north-by-east, Silurian shale dipping very slightly to the south; and on the other side, red rock, which, whenever it is exposed, is found to have an easterly dip.

On the Walsall and Birmingham road, as we rise from the Silurian flat about the Bell, on to the gentle elevation on which the Gough's Arms stands, we meet first with some pale wine-coloured mottled calcareous sandstone, above which, in a brick pit, we find some grey

and mottled clays and marls, with interstratified sandstone bands, that dip apparently east-south-east at 40°. Over these in a field opposite the Gough's Arms is a band of the calcareous conglomerate, just the same as that of Barnford Hill before described, dipping east-south-east at 20°. These are all evidently Permian beds. On the higher ground, where "Quarry" and "Snail's Green" is engraved in the Ordnance map, we find a large gravel-pit opened in the quartzose conglomerates forming the base of the New red sandstone.

Further north we get red sandstone and marl, probably Permian, on a level with the Barr limestone near "the Skip," and following on to the east of Hay Head we find red rocks to the east of a certain curved line, while there are Silurian and Coal-measures on the west of it. The way in which the two little bits of Llandovery sandstone are allowed to peep out at Shustoke Lodge and behind Daffodilly, while over the intermediate space the Wenlock shale appears to come directly against the red rock, may be explained on the supposition that the fault here is a waved and gently indented line, and that as the Silurian beds crop towards the east, when the fault makes an eastward bend, it allows the lower rock to crop out, while when it bends to the west it cuts into higher beds, and of course prevents the outcrop of the lower.

So far I have endeavoured simply to describe facts, and give their most obvious explanation. Still it cannot be denied that there is something yet to be learnt respecting the nature of the boundary of the coal-field between Hay Head and Lappal. We may readily allow the boundary between the red rocks (taking Permian and New red sandstone together) on the one side, and the Silurian and Coal-measures on the other, to be an ordinary fault with a large downthrow to the east all the way from Hay Head south to Sunday Bridge. But we are then driven to the supposition that it splits, and that of the two branches into which it divides, one soon ends in the red rocks, and the other goes on at right angles to the former course* until it meets another fault running parallel to the first, and likewise forming a boundary between the red rocks and the Coal-measures. Now there is, in fact, little or no evidence for this splitting of the boundary fault, and we cannot at all satisfactorily account for the southern termination of the part of it that runs by Barr.

Again, the fault running by Oldbury is certainly a large downthrow to the east, and it certainly forms the boundary line between the red rocks and the Coal-measures at the surface, but it can hardly be called the boundary of the coal-field, inasmuch as the coals are got for a mile or more to the east of it, at only a comparatively slight increase of depth. Not only so, but the Coal-measures appear even at the surface on the eastern side of this fault, both north of the red rocks towards West Bromwich, and southwards towards Wilderness Farm and the Stone House. That this appearance of Coal-measures is due to cross faults cutting off the red rocks in each direction is at present a mere arbitrary and gratuitous supposition, though it is perhaps the most probable explanation of the facts that can at present be given.

Mr. Hull examined and determined the boundaries of the New red sandstone from Hampstead Hill through Smethwick and Harborne, and

* It might give a more natural aspect to the facts, perhaps, if we supposed another branch to spring from the boundary fault between Ray Hall and Small's farm, and run a little north of West Bromwich old church to the fault that cuts off the Thick coal crop of the Hall End colliery. This line of fault would blend with that which certainly runs under the Cross Guns more easily than the one engraved on the map south of Church Vale, or, perhaps, the two together might form steps letting down the Thick coal under Virgin's End, &c.

arrived at the conclusion that the boundary between the New red and that considered to be Permian was not a fault but a natural boundary, a conclusion in which Professor Ramsay believes him to be correct.

We are, therefore, left to mere conjecture as to the lie and position of the Coal-measures below the red rocks east of the line up to which they have been worked.

It will be more convenient now if we go to the northern end of the eastern boundary fault and trace it southwards. In the Brereton colliery they drove through the fault, and found some part of the conglomerates of the New red against the fifteenth coal at a depth of 460 feet. New red conglomerates rest upon the Coal-measures here on the western side of the field without the intervention of any fault, but it does not follow that they are the same beds of conglomerate, and it is quite possible that those found at this depth in the workings are much higher in the series than those found at the surface at Stile Cop and the neighbourhood. The downthrow of the fault, therefore, may be a great deal more than that 460 feet, and there may be a succession of step-like downthrows outside it again. One such step-like downthrow was observed in a gravel pit at no great distance from the spot. Starting from this point along the line drawn on the map to the southward, we have abundant evidence of "Red rock" on one side, and of Coal-measures on the other, lying just below the surface of the ground in a nearly horizontal position. The Red rock is the ordinary Red sandstone of the New red formation. In Beaudesert Park it is apparently one of the soft red sandstones that were formerly called Brick red sandstone; about Cannock Wood the beds are white and brown sandstones, and on Old Lodge Hill are some excavations in red marl that appear to be just the bottom beds of the upper subdivision of the formation, the Red marls. From this point scarcely anything can be seen or known for about two miles, till we arrive at the Hammerwich colliery just east of the dam of the reservoir. In the coal-pits there they drove to the east, and struck the Red rock fault just under where the feeder falls into the new branch of the canal. The Red rock is seen in the canal to be the lower subdivision of the New red sandstone, consisting of Red sandstones and conglomerates, and the coals are known to be in the lowest portion of the Coal-measures. So far we have seen no Permian rocks, though it is quite possible that rocks of that formation lie concealed under the New red sandstone, and between it and the Coal-measures on the downcast side of the great fault.

Nevertheless, no rock considered to be Permian makes its appearance at the surface between the New red sandstone and the lower rocks, till we come south of Aldridge to the neighbourhood of Hay Head and Great Barr, which has been before described.

Somewhere about the Brown Hill, however, it would appear that a split takes place in the boundary fault, and that a branch is sent off into the Coal-measures, ranging down the valley by Clayhanger, and thence to the southward, until it probably meets with or passes into the Linley and Daw End fault that cuts off the Walsall Silurian rocks.

The bottom Coal-measures crop, as before shown, all along the region of Pelsall Heath and the Brown Hills, dipping to the west. East of this outcrop, however, nothing is to be found but the red clays which are now believed to belong to the upper part of the Coal-measure series above all the workable coals. These may be seen lying horizontally or dipping at a very gentle angle to the northward or north-westward at Catshill, and all down by Walsall Wood to Stubbock's Green. From under these red clays the dark coal-bearing measures then rise to the southward towards Linley and Aldridge.

It appears certain that the coals which crop about the Brown Hills, and are known to be cut off by a fault there running north-north-east and south-sonth-west from Watling Street to the canal a little east of Birch Coppice, are thrown down under Clayhanger to a depth of more than 1,000 feet (300 or 400 yards), and that they lie at that depth under all Walsall Wood, forming the bottom part of the Coal-measures from which coals are now being got at the Coppy Hall colliery at Stubbock's Green, and that were proved to exist at the Aldridge Trial pits a little north of Red House.

It seems also certain that the Clayhanger fault must continue somewhere down by Goblins Pit Wood and Shelfield, towards Coal Heath, with a downthrow to the east.

It seems also quite certain that the abrupt northern termination of the limestones of Daw End and Hay Head along a certain line, with the equally abrupt coming in of Coal-measures immediately north of that line is the result of a fault having a downthrow to the north-east, and it is very probable then that the two faults thus proved to have a similar large downthrow, are in reality one fault, forming a branch of the boundary fault. If this be so the eastern boundary fault will form two step-like eastern downthrows from the Brown Hills to Hill End, south of Aldridge, while south of that it again becomes only one downthrow, but not of so large an amount, so that it allows the Permian rocks to appear at the surface on its eastern or downthrow side, instead of bringing down the New red sandstone to the level of that surface.

The Western Boundary fault.—If we begin on the south, we may say that the western boundary fault of the coal-field commences at the northern slope of Wychbury Hill. Thence to Oldswinford we have the Brick red sandstone and conglomerates on one side, and the upper Coal-measures on the other side of the fault. North of Oldswinford we get the Thick coal on the upcast side of the fault, cropping up against it and into it at an angle of 45° west of the "Grange," and on the downcast side we get a narrow band of Permian, soon overlaid by the base of the New red sandstone.

By Penn's Hill and Dennis to Audenham Bank, the beds below the Thick coal crop on the east of the fault, the Thick coal ranging up to it a little south of Brettell Lane, while the red rocks may be frequently seen at the surface just westward of the line drawn on the map.

Near Wordesley the New red sandstone dips at an angle of 20° to the west; the Permian, therefore, must here dip, at least, at as great an angle from the fault. At Bug Pool they sank through the fault down into the Thick coal below in consequence of the great overhanging ("hade," "overlie," "underlie," "inclination,") of the fault. In these pits they had 40 yards of "red rock," and got the Thick coal at 126 yards from the surface. Between Wordesley and Salters Hill, Mr. Bond sank 280 yards (840 feet) in the Permian rock at about 200 yards from its surface boundary, without passing through it into the Coal-measures. At the New Bromley Lane colliery south of the Stand Hills, Messrs. Davis have recently passed through the overhanging fault into the Coal-measures at a depth of 142 feet.

The junctions of the great faults called the Brockmoor, Corbyn's Hall, and Shut End faults with the Boundary fault (or perhaps we should say the separation of these great branches from it) appear to have little or no effect on its character. At Kingswinford the Brick red sandstone of the New red formation comes up against the fault, and we have that sandstone on the one side and the Coal-measures, with the Thick coal 140 yards (420 feet) deep, on the other. Before reaching Himley Park the boundary fault seems to split and let in

between its branches a wide tract of Permian rocks, occupying the eastern half of Himley Park, all Baggeridge Woods, and great part of Penn Common.

Indications of the extension of the west branch of this fault into the New red sandstone were observed as far as the Lloyd farm, by Mr. Beckett of Wolverhampton.

The main part or true boundary fault runs as drawn in the map, with a curved line up to Sedgley Hall farm; quarries or cuttings in the Permian rocks being observed at intervals all the way on one side, and Coal-measures on the other. At the turnpike-gate west of Sedgley some small pits in a patch of Thick coal were worked formerly, and in the year 1828 a trial pit was sunk just east of Sedgley Hall farm. In this trial pit the Thick coal was found at a depth of 323 feet, dipping to the west at an angle represented as only 12°. But as a quarry in the Permian rocks may be seen just north of the farm, and the limestone ridge rises immediately on the east of it, it is clear that there must be a fault on each side of this patch of Coal-measures. Moreover the first 120 feet in this shaft was described as "red croprash rock and marl," which were in all probability Permian rocks. From these facts it is probable that the boundary fault "hades" here, at a comparatively low angle, to the west, leaving a long space of "barren ground" between the ends of the Thick coal on opposite sides of the fault (see Horizontal Sections, Sheet 24, No. 6). This is probably the general character of the boundary fault in the southern part of its course. Along the flank of the Sedgley ridge all we know of the boundary fault is that there are Silurian rocks on the high ground on one side, and Permians in the valley below.

In the Parkfield coalworks beyond, as also in the Cockshutts and Green Lanes collieries, the Coal-measures are very violently broken and contorted,* and a very common feature is a rapid dip of the coal measures towards the fault as they approach it.

Patches of Thick coal were found in the shafts south of the Fighting Cocks dipping at the fault. Lord Ward's agent, Mr. R. Smith, informed me, that at one spot, after the Blue flats ironstone had risen to the surface in the form of an S from a depth of 100 yards, so that one shaft passed through the same measure three times, they sank a shaft a little farther west, in which, after passing through a few yards of "Red rock," they came down to some Thick coal, dipping west at a gentle angle, which they followed for a few yards till they found it cut off by another fault, hading rapidly to the west.

At a pit sunk in the Green Lanes, Wolverhampton, they found the Brooch coal at a depth of 30 or 40 yards (90 to 120 feet), dipping west at 2 in 3 (=34°), but as they sank deeper they found the dip of the beds increasing to 2 in 1† (=63°). This was very close to the line of the fault. At the tunnel of the railway at Wednesfield Heath the New mine coal cropped very gently up towards the fault for several hundred yards, and was exposed in the cutting of the railway.‡ Just at the east mouth of the tunnel they met with the "Red rock," dipping westerly, and the coal as it approached it was likewise seen suddenly to dip

* Not far from the Fighting Cocks a pit was sunk formerly where Mr. Pugh's house stands, in which pit the New mine coal, 6 feet thick, took 30 yards (90 feet) of perpendicular depth to traverse the width of the shaft, 7 feet. It dipped, therefore, at an angle of 81°.

† That is, in a seven-foot shaft, after passing through one measure on the crop side of the pit, they sank 14 feet deep before they left it on the dip side of the shaft.

‡ This is stated from my own personal recollection of the cutting at the time of the formation of the Grand Junction Railway.

towards the west, being much broken. The Blue flats ironstone, 160 or 170 feet below the New mine coal, was worked under the tunnel for nearly 100 yards beyond the end of the New mine coal, which would make the "hade" of the fault not much more than 30° from the horizon. At other places, however, between here and Wolverhampton, the fault seems from the workings to approach very nearly to a vertical. From Wolverhampton to within a mile and a half of Cannock, Permian rocks are believed to be those found below the surface on the downcast side of the fault; but at Wyrley Bank these rocks seem to be dying out, and beyond that the Brick red sandstone and conglomerate of the New red is alone seen. A split of the fault is thought to take place near the Walk Mill, one branch proceeding due north towards Stafford into the middle of the New red, while the other continues to form the boundary of the coal-field as far as Hednesford Pool, when that likewise so far dies out as to allow some of the beds of the New red sandstone to appear on the upcast side of it. The country is here so obscure that it is very difficult to say how this takes place—whether the fault becomes evanescent, or whether the beds of New red sandstone on opposite sides of it stood originally at very different levels in the formation.

The red clays of the Essington Wood brick pits are brought in apparently on this side of the coal-field, in the same way that those of Walsall Wood are brought in on the other. A split of the boundary fault as it ranges south seems to take place about Cheslyn Hey, the upper red Coal-measures making their appearance at the surface between the branch and the main boundary fault. The dip on this western side being to north-west, the black coal-bearing measures rise out to the southward towards the Old Mitre, just as they rise out towards Daw End on the eastern side of the coal-field, the downthrow of the branch fault decreasing in each case towards the south. It is possible that the branch on the western side, which we may call the Old Mitre fault, which is known to have a downthrow of 65 yards to the west thereabouts, runs on to the south till it is cut off either by the New Invention fault, or even till it reaches the extension of the Great Bentley fault.

Position and Lie of the Red rocks surrounding the coal-field.—We will now briefly recapitulate what we know of the Permian rocks surrounding the coal-field, and then describe the position of the beds of the New red sandstone around it.

Permian.—The Permian rocks in the narrow belt which runs S.S.W. from Cheslyn Hey towards Wolverhampton are covered towards the west by beds of conglomerate belonging to the New red sandstone, occasionally seen in situ; but still farther west, Professor Ramsay informs me that brown speckled sandstone (Permian) is seen at one or two places, especially in an old quarry a little to the N.E. of Bushbury Hill, and that the way in which these rocks appear involves the necessity of their being brought to the surface by faults having upthrows to the west, as drawn in the latter editions of the map and in Mr. Hull's Section, No. 45.)

Pale wine-coloured and nearly white sandstones, often highly calcareous, were exposed in the cuttings of the railways at Wolverhampton, dipping sometimes at an angle of 5° or 6° to the west. These were also believed to be Permian sandstones. Just

west of the road, however, near the windmill in Stafford-street, good brick red sandstone, certainly part of the New red, is well shown in a quarry, and appears to be quite horizontal. The new shaft for the waterworks at Goldthorn Hill is sunk entirely in mottled calcareous sandstones and marls of the Permian series. These were said to dip westerly across the shaft at an angle sometimes of 30° (Vertical Sections, Sheet 26, No. 50). On the crest of the hill to the westward are some gravel pits opened in the pebble beds of the New red sandstone, which likewise appear to have a slight westerly dip.

Indications of Permian beds on one side of the boundary and a gravel ridge (pebble beds of the New red) on the other are found from Goldthorn Hill to Penn Common. Permian marls and sandstones may be seen in the lower part of the brook south-east of the Lloyd House, and typical New red sandstone at the mill by the Wood-houses. Near Gospel End, the Permian beds, consisting of alternations of reddish and pale brown sandstones with red marls, and a band of slightly calcareous conglomerate, may be seen in some road cuttings. These Permian beds have everywhere hereabouts a dip of 5° or 10° to the west-north-west. A large mass of calcareous conglomerate, similar to that of Barnford Hill on the east of the coal-field, was found and mapped by Mr. Hull in Baggeridge Wood. At Hawkeswell Rough, north of Himley Park, good New red sandstone is seen apparently horizontal, while on higher ground to the eastward are two quarries of pale Permian sandstone, one of which dips north-east and the other south-east at 10°. A fault, therefore, must here separate the two formations. This is believed to extend northwards into the New red sandstone and southwards across Himley Park to the boundary fault. Just behind Himley Hall the conglomerates of the New red sandstone are well shown in a large cliff dipping north at 10°. Pale slightly calcareous sandstones may be seen about the Streights dipping north-west at 5°.

A narrow belt of Permian rocks just peeps out between the New red sandstone and the boundary fault between Kingswinford and Oldswinford. They consist principally of pale red calcareous sandstone and red marls. At Audenham Bank a concretionary mass of compact pale grey limestone, with a smooth conchoidal fracture, was exposed in the bank of the road lying in some red marl. It did not seem to extend far, however. Professor Ramsay informs me, that in a new road cutting near Dennis, Permian sandstones and marls containing slight traces of the trappean breccia may now be seen dipping west at 10° or 15°.

The Permian district round the south end of the coal-field is the largest and most important one of the neighbourhood, and worthy of a little more detailed description. When the country was first surveyed, no doubt was entertained that the Clent Hills consisted of trap rock, and that the angular fragments seen at the surface and in the small quarries were the local débris of the solid rock below. Professor Ramsay, who spent a day with me there in 1849, concurred in these views, which are those published by

Sir R. Murchison in his "Silurian System." On examining the Lickey Hills, however, it was soon perceived that the angular trap débris there rested on red sandstones, which had not then been separated from the New red sandstone formation. This trappean débris, therefore, was at first taken by myself for local drift, derived from the Clent Hills. In some places, however, it was seen apparently to pass under beds of the New red sandstone age, and therefore supposed there might have been a drift of it during the formation of that rock, and another of more recent epoch, deriving its materials either from the breccias of the New red, or directly from the Clent Hills, or partly from one and partly from the other. While examining some of these angular trap breccias, I was often led to entertain doubts as to their being really any trap *in situ* in the Clent Hills, but the trappean prestige was so strongly upon them that I did not venture to disturb it. The district indeed, though frequently traversed, was not then *surveyed*, as the "red rock" country was left till after the Coal-measures and older rocks were completed. Before even the coal-field was finished, I was called away (in 1850) to Ireland to assume the local direction of the survey there in consequence of my predecessor Professor Oldham's departure for India; and it was not till the year 1852 that I was enabled to return for a short time to complete my work sufficiently to allow of its publication. In the meantime Professor Ramsay and Mr. Hull had examined and made themselves masters of the Permian rocks, as shown in the North of Staffordshire; and Mr. Hull examined and partially surveyed the Permians round the South Staffordshire coal-field. Mr. Hull satisfied himself that the angular trappean breccia belonged to the Permian formation, and was a characteristic portion of it. In the spring of 1852 Professor Ramsay joined me in the district, when I had completed the examination of the coal-field; and we were soon aware that a more detailed and accurate survey of the Permian rocks round the south end of the coal-field was necessary. As I was compelled to go to London in order to make arrangements for the publication of this Memoir and free myself for what had become my more legitimate duties in Ireland, Professor Ramsay very kindly consented to devote some of his own time to the examination of this district; and the following are the results of this examination as he has provided me with them.*

The Clent Hills and Wychbury Hill (formerly considered to be trap, and coloured as such in my own working maps,) consist altogether, as far as their higher portions are concerned, of the angular trappean breccia, with no appearance of any trap *in situ* at all, "the fragments being principally composed of greenstone, with a little sandstone and a porcelanic looking slaty rock like some of those west of the Stiperstones." The beds are rudely stratified, and appear to dip south or south-south-west at an angle of about 5°. This angular trappean breccia may be traced con-

* I have entered on this personal detail in order that I may not seem to be taking more credit than I deserve, and also to strengthen my statements by the authority of Professor Ramsay.

tinuously from from Hagley Park to Broomsgrove Lickey, forming the uppermost of the Permian beds, having always a southerly dip, and passing in that direction under the "pebble beds" or conglomerates of the New red sandstone. The breccia is frequently a very deep red, the fragments being cemented together as it were by a red marly substance. When well exposed it is seen to pass insensibly at its base into red marls, the fragments getting smaller and finally disappearing.

Underneath this are red sandstones and marls, and then a band of highly calcareous sandstone comes in, showing itself under Square coppice at the Lickey, of the limeworks of Newtown, near Hunnington, near St. Kenelm's chapel, and west of the parsonage in Hagley Park. Near the latter spot the pebble beds of the New red appear to overlap the trappean breccia and approach the calcareous band,* running up nearly to the obelisk. They are then cut off by a fault which has been recently exposed in a new gravel pit, and the trappean breccia again comes out to form Wychbury Hill. A similar fault, bringing down the gravel beds to abut against the trappean breccia, is believed to terminate it at the Lickey Hill, just north of "the High House" (see Map). The lower beds of the formation, consisting of red and brown sandstones and marls, with one or two calcareous bands, spread over the country from Hagley Wood to Frankley, Kitwell, and the Lappal tunnel, the beds having, doubtless, a general slight inclination to the southward, with several minor flexures. Another patch of the trappean breccia caps the hill on which the well-known trees called Frankley Beeches stand.

From Frankley the dip appears to be south-south-east, and this inclination brings in the trappean breccia again in that direction, dipping in the lane north of Merrit brook at 20° to the south-south-east. Here all the Permian rocks are cut off to the eastward by a fault, believed to be an extension of the eastern boundary fault; and New red sandstone occupies the triangular district between Shenley Court and Weoley Castle. Brick red sandstone comes in south-east of the last-named trappean breccia, resting on it at one place apparently in a horizontal position, but in another appearing to dip from it at an angle of 15°. This sandstone, together with the Permian and other rocks between it and the Lickey, are all believed to be cut off by a fault running north-east and south-west, which will be described presently. From Frankley the Permian rocks extend northwards to the Lappal tunnel, and then, after being apparently interrupted by the Coal-measure tract running down to the Stonehouse, they occupy a broad band of country, extending northwards, between Oldbury and Smethwick, and thence by Great Barr to the ground between Barr Beacon and Hey Head. This Permian tract has already been described (pp. 11, 12, 177, and 178), when speaking of the Coal-measures as coal is worked through part of it.

* Unless this be the effect of a fault, a part perhaps of the boundary fault of the coal-field.

New red sandstone.—We have now very briefly to examine the position of the rocks forming the New red sandstone formation. The northern part of Cannock Chase consists of red sandstones and pebble beds belonging to the middle and lower portions of the New red. These rocks must dip very gently to the north-north-east, in which direction they pass under the upper red marls on the north side of the rivers Sow and Trent. Similar beds on the east side of the coal-field between Lichfield and Rugeley, having a similar dip, likewise pass under the red marls north of the river Trent. These marls, partly by the northerly dip of their beds, partly by the rise of the ground in that direction, become eventually capped by two large patches of Lias, the one occupying Bagot's Park and part of Needwood Forest, the other spreading round Christchurch on Needwood (see Map, Sheet 72, south-east). The sandstones under these marls rise to the westward also, and crop on the high ground between Ingestre and Stafford; but the bottom parts of the red marls are suddenly brought in again by a downcast fault, which is believed to be an extension of the branch that comes from the western boundary fault near Cannock. In consequence of this depression of the beds, the red marls spread themselves over all the country from Stafford to Penkridge and Brewood as far south as Wrottesley Park, and even to the south of that another patch of them is thought to be brought in by a fault, so as to cap the high ground between the Wergs and Nurton. From this point the middle and lower parts of the New red sandstone are seen to stretch uninterruptedly to the southward, till they are again covered by the red marls of Worcestershire a little south of Bellbroughton.

Between Cannock and Wombourne the general dip of those beds must be to the north-west, both from their passing under the red marls in that direction and from their allowing the Permians to rise from beneath them on the south-east.

From Wombourne to the neighbourhood of Stourbridge they probably scarcely deviate from horizontality, except where they rise to the eastward to allow the Permian beds to appear at the surface, or are tilted slightly on approaching the boundary fault of the coal-field. South of Hagley and Clent the general inclination of the New red must be to the southward, the pebble beds rising on to the flanks of the Clent Hills,* and the red marls setting in south of Bellbroughton and at Chaddesley Corbett, and Elmsley Lovett.† Between these places the red marls are underlaid by a white sandstone exactly similar to that under the marls near Albrighton and about Codsall, Brewood, Penkridge,

* The quartzose gravel or pebble beds of the New red sandstone about Clent and Calcot Hill rest directly on or against the angular trappean breccia of the Permian formation. Notwithstanding the incoherent and easily transported character of the materials of the two formations, their boundary is wonderfully distinct, so much so that it can be traced across ploughed fields merely by the nature of the pebbles and fragments lying on the surface, so little have these been mingled either during the deposition of the New red or at any subsequent period.

† From this to the end of the chapter is an account of the work done by Professor Ramsay, assisted by Mr. Howell.

and Rugeley. Plants were found in it by Professor Ramsay near Bellbroughton similar to those described by Sir R. I. Murchison and Mr. Strickland in their paper in the 5th vol. of the Geological Transactions.

These Worcestershire marls have a general south-easterly dip, which brings in the Lias east of Hanbury. My colleague, Mr. Howell, partly by himself and partly in conjunction with Professor Ramsay, had mapped the red marls continuously from the Lias of Needwood Forest, by Lichfield, Tamworth, and Birmingham, to Droitwich; and Professor Ramsay informs me that this Lias near Hanbury is precisely similar in mineral character to that of the outliers of Needwood in Staffordshire, consisting of "pale clay below, with interstratified beds of pale bluish argillaceous limestone, covered by brownish white, very thin bedded, micaceous sandstone, containing casts of small bivalve shells." The extension of this Lias to the eastward is cut off by an upcast fault running north-west, in which direction the red marls are themselves cut off to the east, and red sandstone brought up against them, probably by the same fault running generally north in a slightly curved line. It is not improbable that this fault runs much farther north, and is in some way connected with the western boundary fault of the coal-field. If so, we have strong presumptive evidence for a fault, running generally north and south with a downthrow to the west for upwards of 40 miles, or from the latitude of Stone to that of Droitwich (see Map, Sheets 72, south-west; 62, north-west and south-west; and 54, north-west).

The New red sandstone between Bromsgrove and the Lickey Hill has a general dip to the south-west and south, and the white sandstone comes in around Bromsgrove, passing under the marls to the southward of it. This white sandstone likewise contains fossil plants at Hill Top near Bromsgrove. It appears to pass laterally as well as downwards, into red sandstone. If we start from the natural boundary of the red marl, south of Bromsgrove, and walk across the country to the pebble beds of the Lickey Hill, a distance of about four miles, we should find that every exposed piece of rock showed a dip to the southward or south-westward, sometimes at an angle even of 10°. Whatever allowance we make, therefore, for undulations of the beds, we must necessarily suppose a very considerable thickness to interpose between the bottom of the red marls and the bottom of the pebble beds. If, however, we pass on to the east side of the Lickey quartz ridge, we shall find the natural boundary of the red marls coming up within a mile of the older rocks, and near Kendal end, within 100 or 200 yards of them. As the beds do not seem to have any greater amount of dip on the east of the quartz ridge than they have on the south-west, we must either suppose the whole of the red sandstone to have thinned out here, and the red marls to overlap nearly the whole of the lower beds, or a very considerable downthrow fault to traverse the east side of the quartz ridge. Moreover, the thick pebble beds lying on the south-west flank of the quartz ridge cannot be traced round its southern extremity, nor seen anywhere to the eastward. It is

probable, therefore, that they are concealed under the other beds there by means of such a downcast fault. Several other faults have been found affecting the margin of the red marls, as may be seen in the map.

We have already mentioned a south-west and north-east fault, supposed to start from the sides of the quartz ridge near the coal-measures, and run to the north-east. This has a downthrow to the south-east, and brings down the New red sandstone level with the ends of the Silurian, Coal-measures and Permain beds, between the Colmers and Mason's Lodge. Farther to the north-east it brings the red marl down against the lower part of the New red, namely, the brick-red sandstone, and it then runs off to the north-east through Birmingham, up nearly to Sutton Coldfield, bringing the red marls down against various parts of the New red sandstone. From the eastward of Sutton Coldfield the red marls stretch to the northward uninterruptedly to those before mentioned, north of the Trent, between Barton-under-Needwood and Abbott's Bromley.

The New red sandstone included between this marl boundary and the coal-field consists of brick-red sandstones near Birmingham, part of the upper Bunter sandstone, lying either horizontally, or dipping very slightly to the east, and allowing of the outcrop of a thickish band of pebble beds that usually form the boundary of the New red towards the Permian district. These pebble beds may be traced, more or less continuously, from the Lightwoods near Harborne to Barr Beacon. They apparently extend eastward a good way about Sutton Park, but they approach the boundary of the coal-field again about the Brown Hills, and coming against the fault are cut off by it, dipping north under the upper part of the New red, and only just rising up and re-appearing at the surface on the high ground west of Brereton, from which place they join on to those of the north part of Cannock Chase. Between Lichfield and Rugeley we have only the upper parts of the red sandstone, those lying just below the red marls as before described; so that if the ground were a little higher, the tops of the hills would all be capped by the red marl, as is the hill at the Old Lodge.

CHAPTER XIII.

On Faults.

The previous Chapters have been confined almost entirely to the description of facts actually observed. In the present Chapter it is intended to make some remarks on the proper use of the term "fault," and on some facts tending to throw light on the origin of faults and their mode of production.

The word "fault" is one of several that have been selected by geologists from the language of practical miners, and adopted as scientific terms. Various synonyms for it are used in different

districts. "Dyke" is the word most commonly used in the north of England, and "trouble," "slip," and other similar terms, often occur. In South Staffordshire the word "thing" is very commonly used instead of "fault." They speak of an "upcast" or "downcast thing."

I am not exactly aware how far "fault" and its synonyms may be used accurately in other mining districts, but in South Staffordshire both "fault" and "thing" are terms which are used by colliers, ground bailiffs, agents, and all concerned with them, in the most vague and puzzling way. These terms are applied to matters of the most incongruous natures, so incongruous that it is impossible to include them under any one general term without introducing great confusion of ideas, and consequently falling into all sorts of blunders in practice.

For instance, we have already seen that a cake of sandstone included in a mass of coal is called a "fault," and though in the preceding pages it has always been spoken of as a "rock-fault," yet that limitation or specification of its nature is not one commonly used in the district. Again, the "rolls" or "swells" in the floor of the coal are called "faults." Mere partial and irregular thickenings or thinnings of a bed are spoken of as "faults." I have even heard the natural outcrop of a bed of coal at the surface, especially if it rose to the crop a little more suddenly than usual, spoken of as "the fault" by many old miners of the district.

One of the most eminent and long experienced coal and iron masters of South Staffordshire gave, as his definition of a fault, on a legal examination, "anything which interrupted and deteriorated the coal." Under this definition dykes and intrusive masses of "green rock" (or trap) would be called faults.

A very intelligent ground bailiff once described to me a "sand fault," which I could not understand till I found it meant the outcropping of the New mine coal into a mass of drift at a depth of 90 feet below the surface.

Mr. Keir, in his account of the district, evidently applies the term "fault" not to the mere fracture and displacement, but to the *substance*, whatever it be, that comes in between the walls of the fissure, or the substance that is met with in place of the coal. This idea of a substance of a different kind from that expected seems to be the prevailing one attached to the word fault, for not only do they call "faults" things such as those above, but I have on several occasions had true faults, such as the Brockmoor or Corbyn's Hall fault, described to me as "not really a fault, but only *a slip*."

Examples of the great pecuniary loss and practical blunders likely to arise from this confusion of ideas might be easily accumulated. I will select two. In the case of the gap in the Thick coal at the Gower colliery, described in page 45, it is clear that whatever cause it was which destroyed the coal, that cause had ceased to act before the Cat heath, or the bed immediately above the Thick coal, was formed; yet the ground bailiff who described it to me was surprised that the fault did not affect the Brooch coal

150 feet above the Cat heath. He, knowing that true faults when found in one bed must necessarily affect all the beds above it up to the surface, and looking at this gap in the Thick coal as a fault, expected to meet a similar gap in the Brooch coal above. He of course, would never have recommended, therefore, any operations in search of this Brooch coal; and much of it might have been left behind if it had not been worked in the adjoining ground, and gradually followed by him over this space against his preconceived opinion as to the possibility of its occurrence.

Another case was a dispute between two gentlemen arising from the uncertainty as to whether "rolls" or "swells" could be considered faults or parts of faults, which involved an expenditure of several hundred pounds, and left the question still undecided.

A. let to B. the Thick coal under a certain tract of ground. This ground was known to be traversed somewhere by a large fault, although its exact place in the ground was not known. The Thick coal was to be got, at a rent of so much per acre, up to the fault wherever it might be, allowance being made for so much of the coal as was injured or diminished by the fault, or by *any branches or offsetts of the fault.* It was found, that in addition to the fault, the Thick coal was traversed by two "swells," "rolls," or "horse backs," (see *ante*, p. 52,) which ran side by side across a part of the ground, diminishing the thickness of the coal by cutting out a certain portion of the lower beds of it. These "rolls," or long ridges, were traversed obliquely by the fault, and it was contended by B., that they were *branches or offsets of the fault*, and he claimed compensation accordingly.

A., however, contended that they had nothing to do with the fault, that they were mere ordinary accidents to be expected now and then in coal mining; and if compensated for at all, were to be so on totally different grounds from those put forward by B.

There can be no doubt that if we construe the agreement technically, according to the only possible accurate definition of the terms, A. was right. It is clear that the "rolls" or "swells" existed before the deposition of the upper beds of the Thick coal, while the fault was produced not only after the deposition of those beds, but subsequently to the formation of the whole of the Coal-measures above them. The "rolls" were traversed by the fault just in the same way as all the other parts and portions of the whole formation were traversed by it, and as they existed long prior to the fault, clearly could not have been produced by it, or be anything like "branches or offsets of it." Owing, however, to the vague and uncertain use of the term fault, which is the "custom of the country," and the confusion of ideas in men's minds as to the real nature and origin whether of beds or faults, as much evidence, and from as respectable parties, was adduced on B.'s side as on A.'s, and the matter was ultimately compromised.

This matter is mentioned here thus prominently because it is clearly a practical point well worthy the attention of those engaged in all coal mining operations. Unless such common terms as that

of "fault" can be assigned a definite technical meaning, it is plain that their insertion into legal documents, agreements, &c., can only be the fruitful cause of error and dispute, leading to much useless expense, and possibly to much needless ill feeling.

The remedy for the correction of error both in practical operations and in legal agreements, depending on the proper understanding of the nature of faults, is obvious. It is that the ground bailiffs, mine agents, and surveyors, the men on whose word and authority these things mainly depend, should have the opportunity of acquiring larger and more accurate knowledge, and more correct ideas, as to the real nature of the matters they are engaged with. A comparatively slight acquaintance with the rudiments of practical and theoretical geology, such as might be acquired by any intelligent person from a few months' instruction from a competent teacher, would be sufficient to produce a perfect uniformity in all such men's opinions as to what was and what was not "a fault." Such instruction would enable every mine agent in future life to observe accurately, and to arrange and record his observations truly and methodically, so that all his subsequent experience would be applied in the right direction, instead of, as is too often the case, in the wrong one, and tend to increase his real knowledge, not to add to his misconceptions.

The South Staffordshire coal-field has been so thoroughly worked and explored, that a study of its faults and dislocations will add something of precision and completeness even to the knowledge of a professed geologist.

It is clear that a single fault, that is a fissure running along one straight or slightly curved line, can only produce a "throw" or dislocation of the beds along *a part* of its course. There must be a point in the fissure where the dislocation begins, from which it increases to a maximum, and another point where it gradually ends, and it is scarcely possible that the mere fissure will terminate at either of those points. Such a fault may be likened to a crack in a deal board which ends in the board each way before it reaches its extremity. It is evident that we can only elevate or depress a portion of the board on one side of the crack above or below the corresponding portion on the other side by pushing it in or near the centre of the crack, and causing that portion to bulge. The protuberance of the bulge will be greatest at this part, and gradually diminish each way to the points, where, though the crack may continue, the parts on opposite sides of it retain their relative position. Such "single-lined faults" are those that extend east and west across the part of the coal-field between Dudley and Bilston. Although single in the centre of their course, they often split into one or two small branches near their extremities. The dislocation may be increased by the measures on one side of the fault being bent up into a bulge along its course, while those on the other are bent down. We may, moreover, conceive it possible for the beds ranging along the fault to have more than one "bend" in them, and thus the amount of the throw to diminish and again increase; and if the beds on

opposite sides of the fault bend in opposite directions, the flexures may cross each other, and thus the fault apparently disappear, and again set on again along the same line.

If now, recurring to the deal plank, we were to make a cross cut to the crack before mentioned, it is obvious that by applying the requisite force near the junction of the two, we might permanently elevate or depress the included corner of wood. We should then have a representation of two faults, each increasing towards their point of intersection. Or if we continue the crack to the edge of the plank, which we may look on as a great boundary fault, we may bend one side so as to make the dislocation gradually increase from its commencement up to its termination. Of the latter case we have examples in the Corbyn's Hall and Brockmoor faults, that gradually increase their "throw" as they approach the western boundary fault.

It follows from the above considerations, that if there be only one or only two lines of fracture they must gradually diminish and end somewhere, and that the dislocated ground must have at least one place of maximum disturbance towards which *it bends down* either in one or several directions.

To have any piece of ground altogether elevated or depressed with regard to the whole of that surrounding it, it is necessary that it be bounded by at least three rectilinear faults, or by such an arrangement of curved fractures as amount in effect to three or more rectilinear ones.

These statements will, of course, be to the geometrician exceedingly simple, and scarcely worth making. The considerations involved in them, however, are sometimes hardly sufficiently attended to in geological surveying. One often sees a mere straight line representing a fault on a geological map, and sometimes is tempted to wonder what becomes of it, or how any mass of beds can be elevated or depressed in consequence of a single crack running through them. That such single-lined fractures do occur, however, the beds on one side bending down, while those on the other have remained stationary, or have perhaps bulged upwards, is proved by the occurrence of the east and west faults, before described, traversing the South Staffordshire coal-field.

The above considerations have to do with the longitudinal extension only of faults, but their vertical extent is equally worthy of study. This, however, is so wide a field that we shall only venture on a small portion of it, the subject of "Trough faults," and refer the reader for other parts of it to the papers of Mr. Hopkins in the "Cambridge Philosophical Transactions," vol. 6, and in the "Philosophical Transactions of the Royal Society of London," vols. 133 and 134, 1842–3, as also to a paper by Mr. Darwin, in the "Transactions of the Geological Society," vol. 5, p. 601.

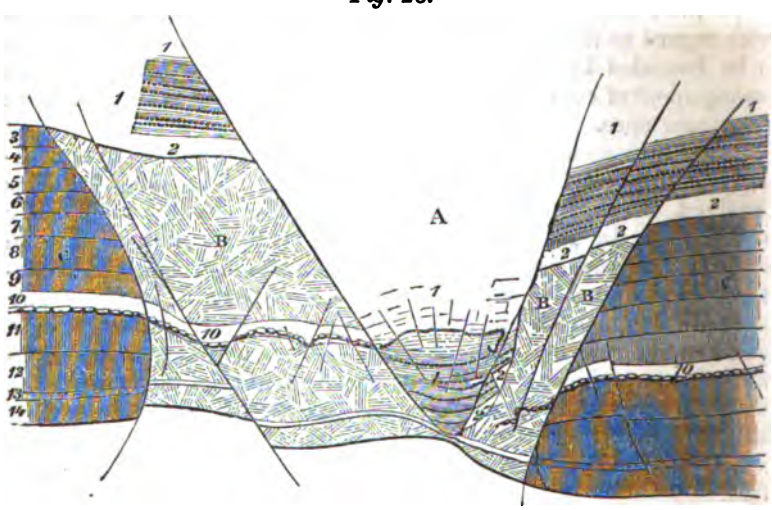
Of "Trough faults" we have several excellent and well-explored examples in the South Staffordshire coal-field, both on a large and small scale. We will take for examination one example of

each, namely, the Dudley Port Trough faults for the large scale, and a small pair of faults in the Victoria colliery, West Bromwich, for the other.

The Dudley Port Trough faults are shown in the section given in this volume (a reduction from No. 7, sheet 25, of the Horizontal sections), and their general form is reproduced in Fig. 28. They have previously been described (p. 164), to which the reader is requested to refer.

Mr. H. Johnson of Dudley, in the year 1849, showed me in his office a carefully-executed drawing of a singular appearance he had observed in the Thick coal in one of the gate-roads of the Victoria colliery at West Bromwich. At this spot the lower beds of the Thick coal were apparently unbroken and regular, but in the three upper beds there was a trough-shaped gap, eight feet wide at bottom and fifteen feet wide at top, in which reposed a corresponding mass of the beds that on either side lay on the topmost bed of the Thick coal. This gap in the coal gradually descended in one direction till it reached the bottom of the Thick coal, and assumed the form represented in the following figure:—

Fig. 26.



Scale, 1 inch equal to 20 feet.

A. Trough-shaped gap in the Thick coal.
B. and C. The Thick coal.
1. Shale and clunch above the Thick coal, containing some bands of ironstone nodules.
2. A black batt (bituminous shale).
3. Roofs.
4. Top slipper.
5. White coal.
6. Lambs.
7. Tow coal.
8. Brazil.
9. Foot coal.
10. Hard stone parting.
11. Stone coal.
12. Sawyer and slipper.
13. Bench batt.
14. Benches coal.

} Thick coal.

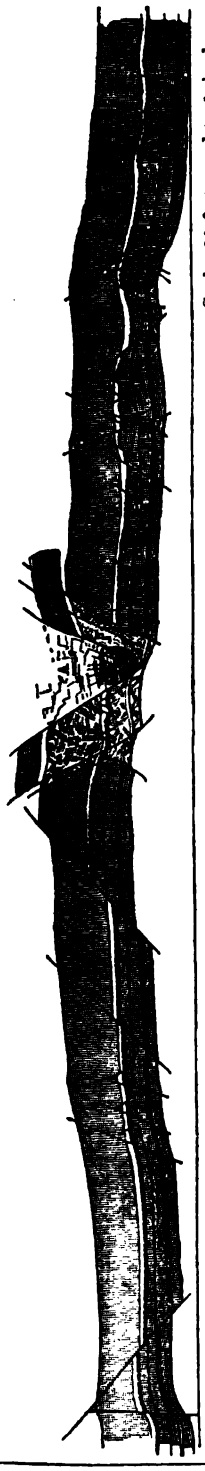


Fig. 27.

The triangular gap A in the Thick coal is filled up by a corresponding portion of the beds above the coal, consisting of shale and clunch, the lower part of which contains several courses of nodular ironstone, marked 1 in the figure. The strata in A are said to be "much broken and contorted, especiall towards the apex. The ends of the strata are turned a little upwards. Two pieces of bituminous shale (2) are found on one side of it, which should under ordinary circumstances occupy the top of the coal." These latter are shown near the right hand of the bottom of the trough in the figure, and marked (2). The trough traverses the coal in a north-east and south-west direction, the bottom of the trough forming an angle with the horizon of 4° 30′.

In the portion of the Thick coal marked C, the lamination and stratification of the coal is uninjured, but in the part marked B, while the stratification is for the most part probably unaltered, as is shown by the "partings 10 and 13 continuing through it almost uninterruptedly, the "lamination of the coal is totally destroyed, and the coal has the appearance of a paste made up of coal dust and very small coal. It appears to have attained its present consistency from compression and not from heat."*

Fig. 27 is a more extended representation of a side of the same gate-road on a smaller scale, that of 60 feet to the inch, its total length being about 150 yards. It is reduced from a much larger drawing of Mr. Johnson's, which was drawn to scale from very careful measurement, every fissure and flexure being as nearly as possible exactly represented.

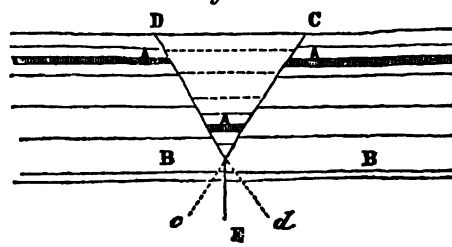
The two drawings given in Figs. 26 and 27 were taken, I believe, in consequence of the explanation I proposed to Mr. Johnson, to account for the appearance mentioned first (p. 194), that in which the trough did not end in a point downwards, but was still eight

* Mr. Johnson's notes.

feet wide at its base. The explanation then given was fully confirmed by these facts since observed and recorded by Mr. Johnson; and as it is applicable to all "Trough faults," and bears on the question of faults in general, it is now given here.

The simplest form of a Trough fault is that represented in Fig. 28, in which a portion of the bed A is dropped down between two

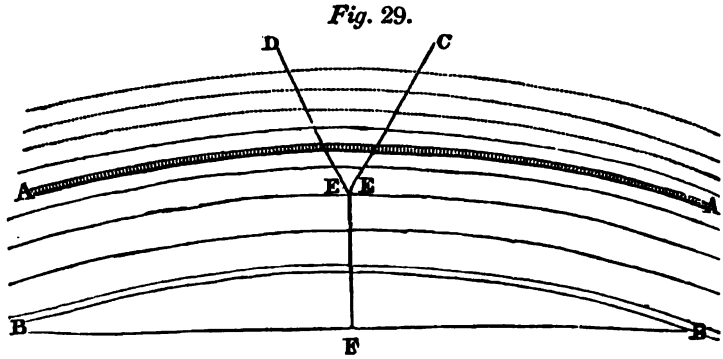
Fig. 28.



equal faults, C and D, which incline in such a manner that they must meet before reaching the lower bed B. It is clear that these faults, having an equal "throw" in opposite directions, must, when they meet, neutralize each other, and that no portion of the bed B can be "thrown" by them either upwards or downwards, or in any direction whatever. We may conceive it possible, however, that C may be continued as a fissure towards *c* or D similarly continued to *d*, though it seems much more likely that they should coalesce and continue in one intermediate fissure E.

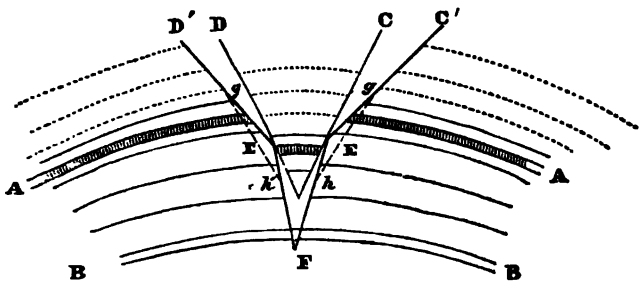
The most obvious explanation of the cause of such a condition of things seems to be the following. Let a set of beds of rock of indefinite extent, among which are two marked ones, A and B, be acted on by an elevating force from below, causing them to bulge upwards as in Fig. 29. Mr. Hopkins has shown us that if this expansion be continued far enough, the result will be the production of one or more longitudinal fissures, commencing at some point *below the surface*. Let such a fissure be produced running from F to E, and at E let it split into two, E D and E C.

Fig. 29.



Now, if the expansive force be continued, and a consequent further elevation take place, it is clear that the beds will assume the further form shown in Fig. 30, the two side portions being still more bent upwards, and the fissure consequently gaping open, so

Fig. 30.



that the lower single fissure F E widens into a triangular gap, and consequently E C spreads to E C′, and E D to E D′. In this case the included triangular mass of beds between D and C must fall down into the open fissure F E. Moreover, as for every inch that the parts A B rise and that E F widens, the included mass D C will settle down into it, the corners at E will be worn and ground down by the friction, so that they will very shortly be ground off to the lines *h g*, which will have the effect of still further widening the fissure, and consequently of admitting the wedge-shaped piece D C to sink further down into it.

Suppose now that the expansive and elevatory force ceases to act, and the upraised beds begin to settle down again towards a horizontal or nearly horizontal position, it is quite possible for the lower part of the fissure E F to close again, and to close in some cases so accurately and perfectly, that if the beds are at all soft and cohesive, scarcely a trace of it may be left after some period of compression. That part of the fissure, however, into which the wedge has sunk will, of course, not be able to close again, but it will strive to do so, and great force of compression will consequently be exerted on the sides of the wedge, and on the beds which come against them. The effect of this compression is shown in Fig. 26 in the destruction of the lamination in the coal marked B B. As, however, the beds sink into a very low arch, the downward pressure on the summit of the arch is made more and more of a horizontal thrust on its sides or abutments, the parts A and B on the sides of Figs. 29 and 30. When the arch becomes very low, the lateral pressure hereabouts must be enormous; and it is important to remark,* that we have here a real cause for bonâ fide *lateral pressure*, and consequent lateral shifting, and even of the sliding of one bed over the other, so that during the subsidence greater dislocations and more crumplings and contortions may take place at the outer ends of the arched beds, or at some distance outside of them, than took place in any part of the beds during the action of the elevating force.

Fig. 27 is an admirable instance of the arched condition of the beds, of the compressed central parts B B, and of the cracks and fissures that are likely to be caused on the sides of the arch as the

* This was remarked to me by Mr. Hopkins, in a conversation I once had with him on this point in the Museum of Practical Geology.

beds sink down again and are endeavouring to adjust themselves to their altered condition, consequent on the intrusion of the wedge A.

As all these actions may take place in nature simultaneously and very irregularly, according to a multitude of varying conditions, we may have a great number of modifications of the simple action here described. Among other things we may easily imagine the apex of the wedge to suffer considerably in some places, and to be ground off till it may have a blunt base, not only of 8 feet, but of many yards in width.

I have spoken before of the benefit Practical Mining might receive from the study of the science of Geology. This case is an instance of the great reciprocal advantage the science of Geology would receive from the observations of practical miners, if they knew what to observe, and how and where to record their observations. In the matter of faults and dislocations in the Coal-measures especially, there are many curious observations yet to be made, and many cases occur that would at first puzzle a geologist, and might be deemed by him impossibilities till he saw them before his eyes. Some of these came partially and imperfectly under my own observation when surveying this coal-field, but they could only be properly described and recorded by a person who was frequently engaged in measuring and drawing them during the progress of works extending, perhaps, over weeks or months.

We may, perhaps, here advantageously say a word or two as to the age of the principal faults and dislocations of the South Staffordshire district.

It is clear that, however the Silurian rocks may have been partially disturbed and denuded before the deposition of the Coal-measures, none of the prominent dislocations and disturbances which give the marked features to the structure of the district, took place till after the formation of the whole of the Coal-measure series. All the great faults, then, are of a later date than the deposition of the newest Coal-measures of the district.

How far the pre-existing rocks were fractured and disturbed at the *commencement* of the Permian period, or during the interval between the deposition of any Coal-measures and that of any Permians, is very difficult to be determined.

From considerations partly derived from this district, partly from other portions of the Midland Counties, it would appear probable that great disturbances, producing both large dislocations and an immense amount of denudation, took place some time during the Permian period, or some time between the period of the Coal-measures and that of the true New red sandstone. I should incline to look on it as possible that the disturbances along the line of the Lickey, and the Dudley and Sedgley anticlinals are of this date, and possibly also some of the principal faults of the coal-field. It is, however, plain, from the description given in the last Chapter, that the great boundary faults of the coal-field were, if not produced, at least largely acted on, subsequently to the deposition of the whole of the New red sandstone, and even to that of the Lias.

It is, of course, quite possible that the first impulse towards these faults, the strain that produced the cracks, was communicated to them at the period when the great disturbances in the Carboniferous rocks took place generally through Britain; and that period seems certainly to have been previously to the existence of the New red sandstone. A further subsidence or elevation, or in other words a relative displacement, may have at some subsequent period, or even at several periods, taken place among these cracks, extending them into the more recently deposited beds of the Red marls and the Lias, and "throwing" those rocks up or down from their original level, as we see to be the case with the Red marls on both sides of the coal-field, and with the Lias south of Bromsgrove.

No one, I think, will now be able to look at a geological map of the centre of England without connecting in his mind's eye the Lias of Worcestershire and Warwickshire with that of Staffordshire and Cheshire, and being convinced that these outlying patches once formed one broad connected sheet, a level plain of Lias spreading over all the intervening districts, and sweeping up into the borders of Wales. Wherever a sufficient thickness of the upper Red marls has been left undenuded, to render it possible for beds of Lias to come in, there we find them; but for the denudation, therefore, we should have found Lias wherever we now find the Red marls. The same reasoning will apply to the several members of the New red sandstone, down to the base of that formation. Wherever, therefore, the New red sandstone spreads (in the Midland Counties, at all events), it was in all probability once covered by Lias.

At all events, it is clear from our previous descriptions, and from an inspection of the maps and sections, that before the production of the dislocations of the great boundary faults, the New red sandstone spread over the coal-field and whole district of South Staffordshire, and we can see no reason why it should not have had the whole of its beds everywhere, or why these beds should not have been everywhere covered by the Lias.

At some subsequent period great dislocations took place, and either the present coal-field was lifted up above the surrounding district, or it was left standing while the surrounding districts were depressed, and thus rising as a great protuberance, was of course subject to the more marked influence, and more complete action, of the denuding agencies which have worn and pared down all the country to its present surface. In this way the lower rocks have been stripped of their former covering in the district forming the present coal-field, while more or less of that covering, according to circumstances, has been left untouched in the surrounding country.

The practical bearing of these remarks is this, that wherever we find any of the upper parts of the New red sandstone, we shall there, in all probability, find all the inferior ones in their proper position below it. To commence sinking for coal, therefore, in any of the parts coloured as Red marl in the geological maps of the Midland Counties, would be only to throw away money; still

more absurd would it be to attempt to find it by sinking in the Lias, as was formerly tried on Needwood forest.* It would even be a very imprudent speculation to attempt to sink for coal within any part of the New red sandstone district, unless it were first clearly ascertained that no great thickness of Permian rocks was likely to occur between the bottom of the New red sandstone and the top of the Coal-measures.

Supposing any one to be desirous of sinking for coal, either in the district between the South Staffordshire and Shropshire, or between the South Staffordshire and Warwickshire coal-fields, and assuming that Coal-measures stretch without interruption beneath, an assumption which the exposed area of the district described would not entirely warrant, he will have to calculate—

1st. The probable thickness of the beds of the New red sandstone he will have to pass through.—This will, in many places, be several hundred feet, let us say 500.

2nd. The possible or probable thickness of the Permian formation.—We have seen reason to suspect that this is in some places, perhaps in many, at least 500 yards, or 1,500 feet in thickness. He might be lucky enough to hit upon a spot where there was none of this; but there would be a great chance against such a piece of good fortune, and he would only act wisely to set this rock down as 1,500 feet thick.

3rd. The probable thickness of the upper and unproductive Coal-measures.—We have seen that in some part of the South Staffordshire coal-field there are 900 or 1,000 feet of Coal-measures above any of the workable beds of coal or ironstone. Our supposed speculator then would, in any place, have a great chance of coming first upon these upper measures, and would do well to calculate on the possible occurrence of 1,000 feet of them before he reached the more profitable beds.

We thus get altogether a total of 3,000 feet, or 1,000 yards, for the probable depth of good workable Coal-measures over the greater part of the space between the South Staffordshire coal-field and those of Shropshire on the one hand, or that of Warwickshire on the other, under the supposition above mentioned.

He must also take into account that after sinking for perhaps 1,000 or 2,000 feet (say 600 or 700 yards) through red rocks, he might find that he had come down upon a place where the Coal-measures are altogether absent, and might find himself penetrating Silurian shale or some other formation that lies below the coal.

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* I may, perhaps, be pardoned for saying here, that even within my own recollection, since the year 1830 for instance, more money has been foolishly expended in the abortive search for coal alone, in places where a geologist would have at once declared against the possibility of finding it, than would have paid the entire cost of the Geological Survey from its commencement to the present time, or its future cost for many years.

Any search for coal through the lias or through the red marl could only be advisable in localities where those formations could be shown by geologists to have, probably or certainly, overlapped the Bunter and Permian beds, and to rest directly on the Coal-measures.

CHAPTER XIV.

On the Formation of Coal.

Coal is universally allowed to be of vegetable origin; it is a mass of the débris of trees and plants, that having been buried under mud and sand, has been subsequently converted into coal, the muds and sands being similarly converted into shales, and clays, and sandstones. There are, however, two opinions as to how the vegetables got into the situation we now find them in. The first, and at one time the more general opinion was, that trees and plants were drifted into large lakes, estuaries, and shallow seas, and there becoming water-logged, sank to the bottom, and were subsequently covered up there by the other accumulations. The second opinion, and perhaps the most generally entertained now, is, that the plants entering into the composition of the coal were not drifted, but grew and perished on the very spot we now find them forming coal, just as our own peat bogs at the present day would form coal if buried for a vast series of years under a great accumulation of earthy matters.

Botanists tell us that all the plants entering into the composition of coal, so far as they have been able to trace and verify any part of their structure, appear to have been not aquatic but terrestrial plants. For the formation of the beds of coal, therefore, *in situ*, it is necessary to suppose that the water in which the shales and sandstones were deposited became filled up, and the space converted into dry land, or, at all events, into a marsh at or above the level of the water; that on this dry land or marsh, plants accumulated in sufficient quantity to form a bed of coal; that then a depression took place, and the space became again covered by water, in which more shale and sandstone materials accumulated, again filling it up to the level of the water, and then another marsh, and so on.

I by no means intend to range myself among the advocates of either one or the other opinion, but I think there are certain difficulties in the way of the latter, which in spite of all the evidence as to the roots* and upright stems of trees, (or whatever the plants called Sigillaria, Stigmaria, &c. may have been,) would make me hesitate to embrace it exclusively. Some of these difficulties arise from facts observed in the South Staffordshire coal-field, and these it is now proposed to lay before the reader.

1st. *The "rolls," "swells," or "horse's backs."*—We have seen, page 52, Fig. 9, that these are long ridge-like accumulations

* Among other evidences is the case described by my friend Mr. Beckett, of Wolverhampton, in the first vol. of the Geological Journal. I afterwards accompanied him to the open work at Parkfields, where these stumps of plants occurred in the coal. They certainly looked as if they had grown there, and perhaps they may have done so, but even so, it by no means settles the whole question.

of clunch or clay rising for sometimes at least 8 feet above the floor of the coal around them. If they were accumulated under water, but the surrounding coal that abuts against their base was begun to be formed at or above the level of the water, we must necessarily suppose an elevation of the ground to have taken place to the amount of 8 feet, between the time of the formation of the "swells," and that of the coal, or else that they were formed during seasons of flood when the waters were 8 feet higher than usual. The structure of these "swells" seems to me a very small foundation on which to build the hypothesis either of a partial eight-foot elevation of the land, or for an eight-foot rise of the water. If, however, both "swell" and coal were formed under water, there is no difficulty in the case.

2nd. *The rock faults in the Thick coal.*—These were described pp. 45 to 51, Figs. 5 to 8. The most obvious questions to put respecting them, when we are inquiring into the origin of coal, are, if the sandstone was deposited in water, and the coal is so intimately and minutely interstratified with the sandstone, how comes it that the coal was not itself deposited in water? or, if the coal is of terrestrial origin, must not the sandstone be so too? The only possible origin * for the sandstone I can imagine on the latter alternative is, that the sand was brought up in among the vegetable matter by means of a strong spring or springs, but whether such an imagination be allowable to account for a mass of sandstone of 250 by 400 yards in extent, at least, must be left to the decision of the reader. There is, perhaps, at first a little difficulty in understanding this local accumulation of sand over a comparatively small area, surrounded by so much almost unmixed coal, even on the supposition of their both being drifted into the place we now find them, and deposited under some considerable depth of water, but in this case it is nothing more than the local occurrence of a cake of sandstone among wide spread beds of clay, or other material, a case which we know frequently occurs in nature.

More recent examination of the sand patches in the Thick coal of the Causeway Green colliery, and accounts of similar occurrences in many other parts of the neighbourhood, and the ending of the Thick coal in beds of sandstone in various directions, have only confirmed me in my belief in the entirely subaqueous deposition of those coals.

The way in which thick and thin seams of sandstone and coal alternated occasionally, with little seams of perfectly bright pure coal in the regularly stratified sandstone, while thick beds of pure bright coal are often flaked by little partings of clean sand throughout their thickness over considerable areas, seems to me to render it impossible to suppose otherwise than that their deposition and stratification was produced by the same agent.

It seems to me absolutely necessary to suppose that the vegetable matter was strewed out in regular thin laminæ at the bottom of

* It is clearly impossible it can have been "blown" sand.

some water, and that occasionally little clouds of fine sand or silt were carried into that water, and likewise sank to the bottom in fine layers. I have no doubt of the process of accumulation being a very slow and gradual one, for I have long been accustomed to look upon the time required for the formation of any wide spread bed of stratified rock whatever, even a single foot in thickness, as one to be measured only by the lapse of scores of years, perhaps by that of centuries. Each bed of coal is certainly made up of thin laminæ, which are obviously laminæ of deposition, every tenth or every hundredth of an inch requiring a distinct period for its production, as in the case of all other laminated rocks. The variations that take place in the quality and character of coals, sometimes inch by inch in their different laminæ, one being less and another more earthy, &c., the separation of the laminæ by little films of shale, or by thicker "partings" of substances that are distinctly argillaceous earth, more or less mingled with carbonaceous matter, those partings occasionally thickening out into substantial beds, and the occasional occurrence of nearly pure quartzose or micaceous sand, sometimes quite free from carbonaceous admixture, either in the thinnest films or in thicker beds, will all then be naturally accounted for by one process, namely, the gradual deposition of laminæ and strata of different kinds of substances, with different degrees of mingling at the bottom of some water.

3rd. *The phenomenon of the Flying reed.*—If the reader will turn to page 39, Fig. 4, he will see that to account for the structure there described, on the principle of all coal-beds being of terrestrial growth, the following suppositions are necessary:—Firstly, the water was filled up to its surface, and on that level plain the Heathen coal was formed, then a depression took place, and a subsequent refilling of the water with earthy deposits, and then the Thick coal was formed. When, however, the accumulation of the vast quantity of vegetable matter necessary for the production of the Thick coal was nearly completed, a very partial and local subsidence took place in one or two localities, bending down the previously formed beds into a hollow or pool of water, sufficiently deep for 128 feet of shale and sandstone to be accumulated, and thus another level floor formed for the growth of the upper bed of coal, which grew partly on the shale and sandstone, and partly on the undepressed coal. Then another depression took place, which was itself very unequal, and had this peculiarity, that over the part previously depressed it only amounted to 38 feet, while over the part not so depressed, and over the district generally, it was from 120 to 180 feet.*

4th. *The expansion of the Thick and other coals towards the north.*—When, however, we extend our observation beyond the

* It seems necessary to suppose that the depressions were unequal, and the irregularities levelled up to the surface of the water, by the accumulation of materials, because, if the depressions were equal over large spaces, and the accumulations of unequal thickness, we should be obliged to call in the aid of unequal elevations or depressions again, to form a level surface "à fleur d'eau," for the growth of the next bed of coal.

mere phenomenon of the Flying reed, and embrace that of the expansion of the whole Coal-measure series to the north, and the splitting up and separation of the coals in that direction, I must confess the idea of those coals being formed only at or above the surface of the water, while all the beds between the coals were deposited below the surface of the water, becomes one that I find it impossible to entertain. It will scarcely be worth while to go into an elaborate argument on this part of the subject, since I think an inspection of the diagram on Plate 1, p. 25, will be of itself sufficient.

It has been formerly pointed out from facts observed in this district, which are in perfect harmony with the well-known facts elsewhere, that single beds of stratified rocks have generally an area greater, and a thickness less, in proportion to the fineness of the materials of which they are composed. When the materials are coarse they are usually heaped together so as to form a thick bed in one place, which gets rapidly thinner in different directions, and often soon ends altogether. When several beds of the same kind of substance rest on each other, so as to form a group or set of beds, the above statement is almost equally true. When, on the other hand, the materials of which a single bed, or any set of beds, is composed are of very fine grain, those materials are generally equally diffused over a very wide area, changes in thickness are rare and occur very gradually, and the bed or set of beds where it comes to an end does so very gradually, and sometimes almost insensibly. When beds of coarse material are interstratified with beds of fine, the changes that take place in the grouping of the beds is often the result, solely or chiefly, of the changes in the coarser members, their sudden terminations, or their sudden thickenings and thinnings; the apparent changes in the thickness of the finer beds is due to single continuous beds or single continuous layers or laminæ being either separated by the partial interposition, or brought together by the partial absence, of the coarser over certain spaces. Now, it is clear that this law of the area of beds and laminæ being greater and their thickness less, in proportion to their fineness of grain, means nothing else than that the materials were spread over a larger space in consequence of their comparatively light specific gravity, or at least of their being more easily and therefore more widely transported by water, and being more generally diffused through it before finally coming to rest at the bottom. It was pointed out before too, that beds of coal so far from forming any exception to this general rule, are its most marked example at the one extreme, while coarse sandstones and conglomerates form the most striking example at the other.

In no Coal-measures that I ever examined in any part of the world, either in the British Islands, Newfoundland, or Australia could I ever detect anything but the most perfect conformity and blending between beds of coal and the stratified aqueous rocks in which they lay, the whole apparently forming one series of deposits produced by one agent acting in one way.

The diagram on Plate 1 confirms these views in perhaps as striking a fashion as could be imagined. The beds of coal are evidently continuous from the northern to the southern part of the field. Each layer of carbonaceous matter has been widely and generally diffused throughout the water on the bottom of which it was ultimately deposited. How it came there, whether it was altogether of extraneous origin and transported from a greater or less distance, or whether it was the result of the death and decomposition of vegetables that grew in the water and were rooted in its bed, or whether some of them grew and some of them were transported thither, or how else the carbonaceous matter came there, is a part of the subject on which I offer no opinion. I wish merely to say as the result of an experience of a good many years, confirmed by the particular instance under examination, that it appears to me that the phenomena of the lamination and stratification of beds of coal, and their interstratification and association with other stratified rocks, are explicable *solely by the relation of the specific gravity of their materials to the action of moving water*, and the consequent diffusion of those materials through the mass of that water.

We know that at all events the materials of the clays and sandstones were transported into that water at intervals, and it appears that in the case of the South Staffordshire coal-field, the principal and most abundant source of these materials lay to the north of the coal-field, and that these materials which were largely and frequently deposited on the north, sometimes failed to reach the more southern part of the area, while the coals were diffused equally, or at least more equally, over the whole area.

If, for instance, we were to examine the constitution of the Bottom coal, commencing on the north and following it to the south, we should learn the following facts respecting,—

First of all about the latitude of the Rising Sun at the Brown Hills, a great number of layers of carbonaceous matter were deposited until eventually enough was accumulated to form a thickness of 5 feet of coal. In whatever way this took place we cannot conceive it to have been otherwise than a long process. No one perhaps has yet formed an adequate conception of the vast length of time and great growth of vegetable life, either on the spot or in the neighbourhood, required for the formation of 5 feet of coal over an area of many square miles. There was then a gradual and successive deposition of several hundred layers of fine black mud forming more than 3 feet of dark shale. This bed is only 2½ feet thick at Pelsall, a mile or two farther south, but in one place becomes 9 feet thick in consequence either of some change in the currents or of some undulation in the bottom, or some other arrestation of the suspended materials. Farther south this bed is not mentioned at all, either because it does not exist at all or because it is too thin to notice. Near the Rising Sun we find over it another series of coal layers forming the Roof coal, which in one pit is a 10-inch and in another a 13-inch coal. At Pelsall, where the

bed below becomes thin, this coal swells out to 3 feet for a short space, while at High Bridge, where the swelling out of the bed below to 9 feet takes place, the coal thins again to 1 foot 9 inches. The deposition, like all other aqueous depositions, was evidently thicker where there was a hollow, and thinner where there was a rise, in the bottom. South of this point where the intermediate bed ceases altogether, the united coal layers continue southwards with a uniform aggregate thickness of 7 feet. Returning to the Rising Sun we find over the Roof coal (which together with the coal below and the intervening bed is spoken of there as the Deep coal) an accumulation of shales and sandstones varying greatly in the details of their grouping and thickness even in closely adjoining pits, but making an aggregate thickness of 41 feet 3 inches in one pit, and 48 feet 10 inches in another. This is in each case covered by the series of layers of coal called the Shallow coal, having an aggregate thickness of 6 feet. At Pelsall Wood the Shallow coal is only 4 feet thick, while the beds between it and the Deep coal are 45 feet, but at High Bridge the coal is 5 feet 2 inches, and the beds below are only 37 feet 9 inches.

From this point the two coals retain their thickness of 5 feet and 7 feet as they range southwards, but the beds between them rapidly thin out, and finally disappear about a mile and a half south of High Bridge. The two coals then come together to form a twelve-foot coal, and continue under the name of the Bottom coal with that thickness for a mile or two to the southward, when they also begin to get thinner and thinner, and finally die out in the district south of Dudley.

This instance, of which the details could be traced, if necessary, through various contiguous collieries in far greater detail, is only one instance of the many similar changes occurring throughout the Coal-measure series. These changes are distinctly referable to the action of water in transporting materials of different kinds that have been committed to it, and cannot, so far as I can see, be referred to any other agency.

If we look at the diagrams on Plate I., with the knowledge of these and similar facts fresh in our minds, and not with the view of extracting a merely possible explanation of it from conceivable circumstances, I think we cennot fail to be struck with the obvious "delta-like" or "bank-like" form which the Coal-measures of South Staffordshire must have originally possessed, and the perfect resemblance they must have had to an undisturbed subaqueous accumulation.

It seems to me then impossible to suppose otherwise than that the whole series of the Coal-measures, coals included, were deposited by one connected operation of the same forces acting in obedience to the same physical laws on similar but slightly differing materials, through an indefinite but immensely long period of time.

The Drift or Superficial Accumulations.

I have reserved to this place the little I have to say on this subject. This little consists of a few fragmentary notices rather than any connected account.

Blocks of granite and old trappean rocks, evidently belonging to the Great Northern drift, are found in great abundance all along the western boundary of the coal-field, especially about Bushbury, and thence towards Cannock. They occur abundantly also over all the New red sandstone country on the west of the coal-field. They may be found occasionally, but by no means abundantly, within the limits of the coal-field itself, but on its eastern side they are, as far as my recollection serves me, comparatively very rare. They are seldom found embedded in any great mass of drift matter, but lie for the most part loosely scattered over the surface of the country.

There is another set of drifted materials which I should be inclined to separate from the Great Northern drift, because large granite blocks are rarely, if ever, found in it, while it often abounds in chalk flints, and sometimes in broken fossils of the Lias and Oolitic formations, and seems, therefore, rather to be derived from the east than the north. This occurs in the shape of sand and gravel lying in patches here and there about the district, or sometimes as a red clay. Red clay, containing water-worn Lias fossils, is frequently found about Wolverhampton, or between that town and Shiffnal, on the cutting of the Shrewsbury railway, resting on the New red sandstone. A block of galena, also, as big as a man's head, was once procured from it near Wolverhampton. It never has been found, so far as I am aware, to contain any fragments of arctic shells, or of any other shells or fossils than those before mentioned as drifted out of other formations.

There is yet another class of drift, apparently distinct from both the above, as never containing any granite or northern boulders, nor any water-worn fossils or recognizable fragments of other formations. It consists, for the most part, of very fine red sand, with a few occasional lines or thin beds of very small well-rounded pebbles, principally of quartz or quartz rock. This occurs in immense quantity about West Bromwich and Hill top, in places between Darlaston and Walsall, and thence towards Willenhall and Pelsall. Large and deep excavations in it may be seen at Moxley Sand hole,* between Wednesbury and Bilston, whence it runs in a pretty well defined band, about a quarter of a mile wide, up to Marshend, a little east of Wednesfield. It makes no feature at the surface of the ground, but comes in suddenly 50, 60, or 100 feet deep, filling up a pre-existing valley in the Coal-measures, and causing great trouble to those who have to sink through it to the beds below. North-east of Wednesbury the New mine coal

* Some men working in these sand holes assured me that a stag's antlers had once been found in this drift at a depth of 40 or 50 feet below the surface.

suddenly crops into this loose sand at a depth of 90 feet below the surface of the ground.

This loose red sand seems to be the washing of the adjacent New red sandstone, and when it is a little consolidated, which it sometimes is, and only a small section of it is exposed, it is extremely difficult to distinguish it from undisturbed New red. This is especially the case about Pelsall and Pelsall Heath. I should class with this drift, in time and manner of accummulation, those quartzose gravel beds which do not belong to the New red sandstone, but which are derived from the washing of its "pebble beds" or conglomerates. These occur very abundantly in some places; they were well shown formerly in the deep cutting of the canal at Smethwick. They spread over all the southern part of Cannock Chase, resting on the Coal-measures there, having been brought probably from the undisturbed pebble beds or conglomerates of the New red, which form the northern portion of the Chase.

Whether these three sorts of drift all belong to one and the same period, that commonly known by the name of the glacial period, is a problem yet to be solved. I may be pardoned, perhaps, for saying that I think many geologists are too hasty in speaking of all superficial drifted materials as "*the drift*," as if there could only be one drift. We have already seen that there was both a Permian and a New red sandstone drift, portions of which, when they appear isolated at the surface, would be taken by any one for parts of the "glacial drift," at first sight.

I know of no reason, for instance, why the drift clay, and sand and gravel containing Chalk flints and Lias fossils, might not be of the age of the gravels of the Plastic clay, though I am not at all disposed to assert that they are so, because, as I know of no evidence against such supposition, neither do I know of any reason for it.

If it be true that stags' antlers were found under the red sand at Moxley, it would, of course, be a proof of its comparatively recent origin; but in the absence of that or some such proof, I should hold myself prepared to find that these sand and gravel washings of the New red sandstone were of any age from that of the Oolites down to the Pleistocene.

CONCLUSION.

No one can be more sensible than myself of the deficiencies of the preceding pages. The work was executed on the Ordnance map of the scale of one inch to the mile, there being no other of similar accuracy on a larger scale. A more detailed survey might have been made had there been a map on the scale of six inches to the mile, such as that of the Townland Survey of Ireland (by the

aid of which the geological survey of Ireland is carried on), or the similar map now in progress in the north of England. Such maps show every natural and artificial feature on its proper scale, and leave room for the insertion of all the requisite data in a distinct form, and without any distortion.* With such a map it would have been possible to have had a separate survey of the Thick coal, showing its depth below the surface at any locality, the nature and magnitude of the faults traversing it, and the extent of injured coal or barren ground caused by them; the places where the coal was injured by trap rock, and the amount of the damage; the districts, such as the large swamp in the centre of the coal-field, where it is now under water, the probable area and depth of that water, and consequently the power necessary to drain it; the spaces over which the Thick coal has been either partly or wholly extracted, and those where it is still untouched; and all other needful and useful information respecting it might thus have been brought together in a compendious form of the highest importance and utility to the practical miner. Every other important bed of coal and ironstone could have been laid down on its separate map, showing its extent, depth, thickness, richness, and the places where it had and where it had not been gotten.

Every one who has had anything to do with coal mining, even as a spectator, must be aware of the great waste of money, labour, and materials, consequent on the division of property among many small owners, each having different and opposite interests. Were the South Staffordshire coal-field now untouched and the property of one individual, there is no doubt that, as far as the mere economical extraction of its minerals is concerned, it might be worked under one well-considered system with infinitely less cost and far greater profit than it has been. The subdivision of property has, of course, great advantages on its side to counter-balance this disadvantage; but the carrying out such a survey as that I have named, while it would not at all interfere with the advantages arising from the subdivision of property, would render it possible to avoid all or most part of the disadvantage, because every one would know the exact state of the ground around him, and mutual agreements might thus be entered into as to the time and method of each working his own piece of land to the best advantage.

In the meanwhile it is hoped that the present general survey of the South Staffordshire coal-field will be found of considerable practical utility, since it has enabled us to combine into a general view much information that had hitherto been only scattered piece-meal about the district, to give a little more definite and common direction, perhaps, to the ideas hitherto floating loosely in many men's minds, as also to warn men off the districts where

* After some years' experience in working on the 6-inch map of Ireland, I can speak authoritatively as to the importance and value of such a map for geological surveys.

costly speculations will be almost sure to be unrewarded, and in some degree to point to those where they are most likely to be successful.

In conclusion, I have to make my acknowledgments to my many kind friends in South Staffordshire for much assistance, without which the survey could never have been rendered so accurate and complete even as it now is. I never made a single application to any landowner, coalowner, or ironmaster of the district, or to their agents, ground bailiffs, and men of business, for any species of information, that was not instantly and courteously responded to in the most ample manner. To enumerate the names of persons I have been thus indebted to would be to give a list of a large part of the population of the district; and is therefore obviously impossible. It is, however, only justice to state, that when the survey of the district was commenced, several of the principal faults traversing it had been laid down on large parish maps by some members of the Dudley Geological Society. Messrs. W. Sparrow and H. Beckett had done this for the district between Wolverhampton, Walsall, and Wednesbury, and Messrs. S. H. Blackwell and C. Twamley for the district around Dudley. The results of their labours were freely communicated, and after being verified, are now published in our maps. Several other gentlemen have been mentioned by name in the preceding Memoir as having afforded important information, and many more might have been mentioned, but that the information they so kindly gave became worked into the general account of the district, and did not relate to any particularly prominent and salient points of its structure.

APPENDIX.

In speaking of the inclination of a bed, or of a fault, or any other plane, it is common in South Staffordshire to describe it by saying how many inches it deepens, or dips, in a yard. In many other districts this is done by saying how many feet or yards it dips or inclines in the hundred. Geologists usually describe the dip by stating the number of degrees of the angle included between the plane of the bed, &c. and the plane of the horizon. It is often very useful in field surveying to know at once, roughly, how these things correspond, for which purpose I wrote out the following table for my own use, and add it here, as it may be useful to others :—

Nearest degree of dip, or each 1 in 100, answering to each inch in a yard.

Inches in a yard.	In 100.	Nearest degree.	Inches in a yard.	In 100.	Nearest degree.
1	2·78	1⅓°	19	52·82	28°
2	5·56	3°	20	55·60	29°
3	8·34	5°			
4	10·12	6°	21	58·38	30°
5	13·90	8°	22	61·16	32°
			23	63·94	33°
6	16·68	10°	24	66·71	34°
7	19·46	11°	25	69·50	35°
8	22·24	12°			
9	25·02	14°	26	72.28	36°
10	27·80	16°	27	75·06	37°
			28	77·84	38°
11	30·50	17°	29	80·62	39°
12	33·36	19°	30	83·40	40°
13	36·14	20°			
14	39·92	21°	31	86·18	40½°
15	41·70	23°	32	88·96	41°
			33	91·74	42°
16	44·48	24°	34	94·52	43°
17	47·26	25°	35	97·30	44°
18	50·04	26°	36	100·00	45°

When the inclination is greater than 45° it is commonly sufficient to say that a bed, &c. dips two yards in a yard, three yards in a yard, &c., &c.

Now 1 in 1 = 45°
2 in 1 = 63° nearly.
3 in 1 = 71° nearly.
4 in 1 = 76° nearly.
&c. &c.

Another way of describing the inclination of the beds is also not unfrequently used, namely by saying that they dip at the rate of one

yard or foot in so many yards or feet. The following table gives the latter number for each of the angles mentioned.

Angle of dip.	Incline of	Angle of dip.	Incline of
1°	1 in 57	8°	1 in 7
2°	1 in 29	9°	1 in 6
3°	1 in 19	11°	1 in 5
4°	1 in 14		
5°	1 in 11	14°	1 in 4
		18°	1 in 3
6°	1 in 10	26°	1 in 2
7°	1 in 8	45°	1 in 1

Another table that is often found useful in geological surveying is one that for every degree of dip of a bed, &c. will give its depth from the surface (supposed to be a horizontal plane) at a distance of 100 feet or yards, measured in the exact direction of the dip. In the following table this is given for every degree up to 20°, and for every five degrees after that; and also the thickness of any set of beds thus inclined, measured, not perpendicularly to the surface but perpendicularly to the dip, in other words, the thickness they would have if they were horizontal.

Horizontal distance = 100.

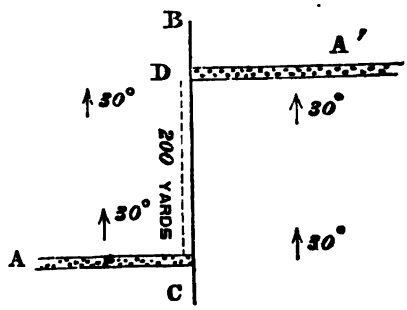
Angle of dip.	Depth.	Thickness.	Angle of dip.	Depth.	Thickness.
1°	1·7	1·7	18°	31·8	30·9
2°	3·5	3·5	19°	34·5	32·6
3°	5·3	5·3	20°	36·6	34·2
4°	7·0	7·0			
5°	8·8	8·7	25°	46·9	42·3
			30°	58·0	50·0
6°	10·6	10·5	35°	70·5	57·4
7°	12·3	12·2	40°	84·2	65·6
8°	14·1	13·9	45°	100·0	70·7
9°	16·0	15·6			
10°	17·7	17·4	50°	119·0	76·6
			55°	143·0	81·9
11°	19·5	19·1	60°	174·0	86·6
12°	21·4	20·8	65°	214·0	90·6
13°	23·2	22·5	70°	275·0	94·0
14°	25·2	24·2			
15°	26·9	25·9	75°	368·0	97·0
			80°	575·0	98·0
16°	28·7	27·6	85°	1143·0	99·0
17°	30·7	29·2			

As this table is one giving the solution of a right-angled triangle for each angle specified, it may be readily used to find any dimension which can be stated in the form of a right-angled triangle, as for calculating the space between the outcrop of two beds, of which the angle of dip is known and the thickness between them; the distance which any bed, of which the depth and inclination are known, will require before its outcrop at the surface can occur; and so on.

By means of this table, also, the probable "throw" of faults can be ascertained, where the broken ends of a bed on opposite sides of a fault

can be found, and a certain mean angle of dip assigned to the whole mass.

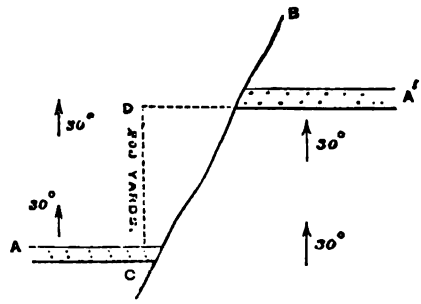
Fig. 31.



If, for instance, Fig. 31, there be a set of beds, including one particular bed A A′ dipping at 30° in one direction, traversed by the fault B C running in the direction of the dip, and the ends of the bed A A′ on opposite sides of the fault be any distance apart, say 200 yards, then, inasmuch as the bed A would by the table be twice 58=116 yards deep at D on one side of the fault while it is at the surface of the ground (supposed to be a horizontal plane) on the other side of the fault, it is obvious that the fault B C has a "downthrow" of 116 yards towards D.

If the fault traverse the beds obliquely to the strike, as in the following figure—

Fig. 32.



—we must, instead of measuring along the fault B C, of course, measure A D along the dip, and then proceed as before.

Conversely when the amount of the throw of any fault, and the angle of inclination of the beds, are known, if the place of the bed on one side of the fault be ascertained, that of its outcrop on the other side of the fault may be calculated, and so on.

Oblique Sections.

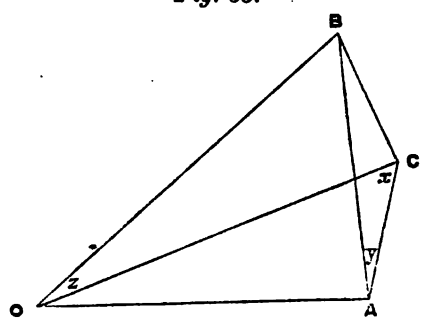
Although it has no especial reference to the district of South Staffordshire, I would yet take this opportunity of printing and publishing the additional table below.

In the year 1850 we were engaged in running sections across a very contorted district of North Wales, so contorted that it was impossible to contrive any long continuous section that should not in some part of its course cross both beds and cleavage planes very obliquely. It became important, therefore, to know what correction to apply to the observed angle of dip of those beds and planes, so that they should be

drawn in the sections correctly with the dips they would actually appear to have in a vertical cliff if one were formed along the line of section. Although the little trigonometry I ever possessed had long grown rusty from disuse, I yet contrived to puzzle out a formula which should express this correction, and from that calculated the table.

Subsequently, however, I lost the clue which had led me to the results, and became doubtful as to their correctness; I therefore applied to my friend Mr. Hopkins, then President of the Geological Society of London, and he, with his usual kindness, favoured me with the following solution of the problem, which I was glad to find gave the same result as that at which I had arrived by a more roundabout and empirical course.

Fig. 33.



Let O A be a horizontal line on the surface of a bed, it will be the direction of the strike: O C the direction of the section as given by the compass, O C being also horizontal.

Draw A C in the same horizontal plane as O A and O C, and at right angles to O A, A C will be the direction of the dip as given by the compass.

Draw C B, *vertical,* to meet the surface of the bed in B, and join A B and O B.

The angle C A B will be the real dip, and C O B the apparent dip, of the bed, as seen in the face of the supposed cliff or section.

Let O C A = x, the angle which the section makes with the direction of the dip,

C A B = y, the real dip,

C O B = z, the apparent dip,

$$\text{then } \tan. y = \frac{\text{B C}}{\text{A C}}$$

$$\text{but B C} = \text{O B} \sin. z$$

$$\text{and A C} = \text{O C} \cos. x = \text{O B} \cos. z \cos. x$$

$$\therefore \tan. y = \frac{\tan. z}{\cos. x} = \tan. z \sec. x$$

or to radius r

(1) $r \tan. y = \tan. z \sec. x$

and $\therefore$ log. tan. y = log. tan. z + log. sec. x − 10;

(2) or $\tan. z = r \dfrac{\tan. y}{\sec. x}$

$\therefore$ log. tan. z = 10 + log. tan. y − log. sec. x.

(1) Giving the *true* dip if the apparent dip were observed in a cliff.

(2) Giving the *apparent* dip that ought to be drawn in the section when the true dip is known.

From this formula the following table has been calculated:—

OBLIQUE SECTION TABLE.

Angle between the direction of the dip and that of the section.	ANGLE OF THE DIP.																	
	10°	15°	20°	25°	30°	35°	40°	45°	50°	55°	60°	65°	70°	75°	80°	85°	89°
10°	9° 51′	14° 47′	19° 43′	24° 40′	29° 37′	34° 36′	39° 34′	44° 34′	49° 34′	54° 35′	59° 37′	64° 40	69° 43′	74° 47′	79° 51′	84° 56′	89° 59′
15°	9° 40′	14° 31′	19° 23′	24° 15′	29° 9′	34° 4′	39° 2′	44° 1′	49° 1′	54° 4′	59° 8′	64° 14′	69° 21′	74° 30′	79° 39′	84° 50′	89° 59′
20°	9° 24′	14° 8′	18° 53′	23° 39′	28° 29	33° 21′	38° 15′	43° 13′	48° 14′	53° 19′	58° 26′	63° 36′	68° 49′	74° 5′	79° 22′	84° 41′	89° 58′
25°	9° 5′	13° 39′	18° 15′	22° 55′	27° 37′	32° 24′	37° 15′	42° 11′	47° 12′	52° 18′	57° 30′	62° 46′	68° 7′	73° 33′	78° 59′	84° 29′	89° 54′
30°	8° 41′	13° 4′	17° 30′	22° 0′	26° 34′	31° 14′	36° 0′	40° 54′	45° 54′	51° 3′	56° 19′	61° 42′	67° 12′	72° 48′	78° 29′	84° 14′	89° 51
35°	8° 13′	12° 23′	16° 36′	20° 54′	25° 18′	29° 50′	34° 30′	39° 19′	44° 19′	49° 29′	54° 49′	60° 21′	66° 3′	71° 53′	77° 51′	83° 54′	89° 47′
40°	7° 41′	11° 36′	15° 35′	19° 39′	23° 51′	28° 12′	32° 44′	37° 27′	42° 23	47° 38′	53° 0′	58° 40′	64° 35′	70° 45′	77° 2′	83° 29′	89° 42′
45°	7° 0′	10° 4′	14° 25′	18° 15′	22° 13′	26° 20′	30° 41′	35° 16′	40° 7′	45° 17′	50° 46′	56° 36′	62° 46′	69° 14′	76° 0′	82° 57′	89° 35′
50°	6° 28′	9° 46′	13° 10′	16° 41′	24° 21′	24° 14′	28° 20′	32° 44′	37° 27′	42° 33′	48° 4′	54° 2′	60° 29′	67° 23′	74° 40′	82° 15′	89° 27′
55°	5° 46′	8° 44′	11° 46′	14° 58′	18° 19′	21° 58′	25° 48′	29° 50′	34° 21′	39° 20′	44° 46′	50° 53′	57° 36′	64° 58′	72° 55′	81° 20′	89° 15′
60°	5° 2′	7° 38′	10° 19′	13° 7′	16° 6′	19° 18′	22° 45′	26° 33′	30° 47′	35° 32′	40° 54′	46° 59′	53° 57′	61° 49′	70° 34′	80° 8′	88° 0′
65°	4° 15′	6° 28′	8° 45′	11° 9′	13° 45′	16° 29′	19° 31′	22° 55′	26° 44′	31° 7′	36° 12′	42° 11′	49° 16′	57° 37′	67° 21′	78° 19′	87° 39′
70°	3° 27′	5° 14′	7° 0′	9° 3′	11° 10′	13° 26′	16° 0′	18° 53′	22° 11′	26° 2′	30° 39′	36° 15′	43° 18′	51° 55′	62° 45′	75° 39′	87° 5′
75°	2° 37′	3° 58′	5° 23′	6° 53′	8° 30′	10° 16′	12° 15′	14° 30′	17° 9′	20° 17′	24° 8′	29° 2′	35° 22′	44° 1′	55° 44′	71° 20′	86° 9′
80°	1° 45′	2° 40′	3° 37′	4° 37′	5° 44′	6° 59′	8° 17′	9° 51′	11° 41′	13° 55′	16° 44′	20° 30′	25° 30′	32° 57′	44° 33′	65° 15′	84° 15′
85°	0° 53′	1° 20′	1° 49′	2° 20′	2° 53′	3° 30′	4° 11′	4° 59′	5° 56′	7° 0′	8° 35′	10° 35′	13° 23′	18° 1′	26° 18′	44° 54′	78° 41′
89°	0° 10′	0° 16′	0° 22′	0° 28′	0° 35′	0° 42′	0° 50′	1° 0′	1° 11′	1° 26′	1° 44′	2° 9′	2° 45′	3° 44′	5° 39′	11° 17′	44° 59′

The use of this table is obvious without much explanation. A single example will suffice. Suppose a section be drawn running north-east and south-west, and it crosses certain beds dipping north at 35° (or certain cleavage planes, or a vein, or a fault, or any other plane having that dip), what angle ought we give to those beds in the section in order to give a true representation of the apparent dip they would have in a cliff running parallel to the section ?

In this case the angle between the direction of the dip and that of the section, or between north and north-east = 45°, which we look for in the vertical column on the left of the table, the angle of the dip =35°, which we find in the horizontal column at the top of the table. At the intersection of these two lines in the body of the table we should find 26° 15′, the angle required.

In practice the minutes of the angle are never required, but as it involved no extra trouble to insert them they are given, as the table might possibly be of use in other ways where more minute accuracy is requisite.

It is plain that the table can be equally used to find the *true* dip where the *apparent* dip only can be observed in a real cliff, provided the angle between the line of section and the strike (and therefore the direction of the true dip) of the beds can be ascertained. This, however is a case which rarely occurs in practice. When it does, of course the nearest angle to the observed apparent dip will be sought in the body of the table, on the line opposite to the angle between the direction of the cliff and that of the strike ± 90°, and the angle of the real dip answering to it will be found at the top of the table.

Note on the Stigmaria Beds of the South Staffordshire Coal-Field. By Sir Henry de la Beche, C.B., F.R.S., &c.

The coal-field of South Staffordshire forms no exception to the other coal-fields of Great Britain as regards the occurrence, in certain of its beds, of the peculiar fossil roots known as *Stigmaria*, in their relative places of growth. These vegetable remains, long considered as the stems of a distinct fossil plant, are now known, chiefly through the researches of Mr. Binney* in England, and of Mr. Brown† in Nova Scotia, to be the roots of the fossil genus *Sigillaria*, or of some other of the like kind of plants.

Mr. Steinhauer would appear (in 1818) to have been the first to have observed the mode of occurrence of *Stigmaria* in certain beds of the coal measures, in a manner pointing to their growth in the bed where they are thus found. Speaking of the rootlets or fibres, as he terms them, diverging from the main *Stigmaria* root, he remarks that "on examining

* Mr. Binney's observations respecting the trees discovered at St. Helen's, Lancashire, were made known to the meeting of the British Association for the Advancement of Science, in June 1845, and his description of the *Sigillaria* terminating in *Stigmaria*, found at Duckinfield, seven miles east of Manchester, was read before the Geological Society of London, in April 1846, and published in their Quarterly Journal, with figures, vol. ii. p. 390.

† Mr. Brown read a paper before the Geological Society, on the same day (22nd April 1852), with Mr. Binney's last-mentioned paper. It is also published in that Society's Journal, vol. ii., and is entitled "On a Group of Erect Fossil Trees, in the Sydney Coal-field at Cape Breton." He gives figures of an upright *Sigillaria* stem with branching *Stigmaria* roots.

the projecting ends of some trunks (of *Stigmaria*) which lay horizontally in a bed of clay, extending along the southern bank of the rivulet which separates the townships of Putsey and Tong, and which is exposed in several places, it excited no little surprise to find traces of these fibres proceeding from the centre cylinder in rays through the stratum in every direction, to the distance of twenty feet." He further inferred that these fibres or rootlets "belong to the trunks in question, and, consequently, that the vegetable grew in its present horizontal position at a time that the stratum was in a state capable of supporting its vegetation, and shot out its fibres in every direction through the then yielding mud."*

Though the evidence on this head is common to all the coal-fields of Great Britain, and can be so readily obtained in many localities, the subject did not engage much attention until Mr. William Edmond Logan,† examining the coal measures of Glamorganshire and Carmarthenshire, was not only enabled to confirm the views of Mr. Steinhauer, but also to ascertain (in 1833) the important fact that all the coal-beds of that district reposed on such beds. When the Geological Survey entered upon the examination of the Coal-measures in the vicinity of Swansea in 1837, Mr. Logan pointed out the *Stigmaria* beds as constantly beneath the coal.‡ In verifying the beautiful maps and sections of the western portion of the South Welsh coal-field, which, with a generous love for the advancement of knowledge, Mr. Logan presented to the Geological Survey, and which were subsequently published by it, abundant opportunities were afforded for ascertaining the truth of this view, one still further confirmed, as might have been anticipated, by the general examination of the whole coal-field of that portion of Great Britain. The Survey in its progress among many other coal-fields of the country, has always observed similar facts, and hitherto, including South Staffordshire, the connexion between coal and *Stigmaria* beds has, with few exceptions and many of these doubtful, been found constant.

Having had occasion to visit nearly all the Coal-measure districts of Great Britain, from those of Scotland on the north to those of Somersetshire on the south, inclusive, I twice visited the South Staffordshire coal-field, and in all the cases where opportunities were afforded for examining the beds beneath the coal, found *Stigmaria* in them occurring as in their relative places of growth. Dr. Joseph Hooker in 1847, (then botanist to the Geological Survey,§) having directed his attention at that time especially to the structure of *Stigmaria*, and having had occasion, therefore, to examine into the subject with much detail, found these *Stigmaria* beds common ;‖ Mr. Dawes, of Southwick House near Birmingham, who has given so much attention to the fossil botany

* American Philosophical Transactions, new series, vol. i.

† Now Sir W. E. Logan, Director of the Geological Survey of Canada.

‡ It was not until February 1840 that Mr. Logan communicated his knowledge of this circumstance to the Geological Society of London, in a paper entitled "On the Character of the Beds of Clay immediately below the Coal-Seams of South Wales, and on the Occurrence of Boulders of Coal in the Pennant Grit of that District." This memoir was published in the Transactions of that Society, vol. vi., 1842.

§ An appointment held by Dr. Hooker until his Botanical Mission, for the Government, to India, towards the end of 1847. The results of Dr. Hooker's researches are published in the Memoirs of the Geological Survey, vol. ii. part 2, p. 431, in a paper entitled "On some Peculiarities in the Structure of Stigmaria."

‖ Subsequently Professor A. Ramsay (Local Director of the Geological Survey of Great Britain) and Mr. Warington Smyth (Mining Geologist to the Geological Survey of the United Kingdom) examined the *Stigmaria* beds in their official visits to the district.

of the district, considers that all the coal-beds in it are based on *Stigmaria* beds.*

In studying these beds care is needed in seeing that the rootlets of the *Stigmaria* really diverge from the main root, and permeate the bed in which they may be discovered, in the manner in which the roots of the water lily (as pointed out by Dr. Hooker) and those of many other aquatic plants permeate the silt beneath still waters. Portions of the main *Stigmaria* roots and even of the rootlets are to be found in the other beds, washed out of their soils (*Stigmaria* beds) and drifted like the stems of *Sigillaria* to which they belonged. From not distinguishing between the *mode of occurrence* of the *Stigmaria* and their rootlets in the different beds, the not unfrequent mistake has arisen of considering the remains of *Stigmaria* as so diffused throughout the various coal-measures that no conclusion can be drawn respecting their mode of growth in place.

In South Staffordshire, as in the other Coal-measure districts of Great Britain, the composition of the inorganic portions of the *Stigmaria* beds varies considerably, as, indeed, might be anticipated from its detrital mode of accumulation. At the same time the number of instances in which the mineral matter of these beds is of a character to afford good materials for fire-bricks, and is hence known as *fire-clay*, is somewhat remarkable. By reference to the Vertical Sections of the Geological Survey, Sheets 16, 17, and 18 (all relating to South Staffordshire), the numerous instances of fire-clays beneath the coal will be at once seen; and so far as my experience has extended the fire-clays so situated contain the *Stigmaria* roots, with every appearance of growth in place. At times it requires careful observation to detect the *Stigmaria* roots in the beds containing them, as well beneath the beds of coal, sufficiently important to have names assigned them, as beneath mere seams of an inch or two in thickness. As will be readily understood, even all traces of a coal above a *Stigmaria* bed may be absent, either from the carbonaceous matter having been removed by the stream or current of water which deposited new matter, such as sand, above it, or from the conditions not having been so far advanced as to permit the *Stigmaria* bed or soil to be coated over with such carbonaceous matter.†

Seeing the general occurrence of the *Stigmaria* beds beneath those of coal, a proper appreciation of them may become, as it has been already found in some districts, practically useful in tracing the outcrop of beds, especially where the crop of a coal itself may be uncertain, and the thickness of a *Stigmaria* bed may be considerable, though the latter necessarily, seeing the respective origin of the two, bears no relation to that of any coal which it may support, or be intermingled with.‡ When

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* Dawes, MSS.

† In some coal districts, as, for example, in South Wales, the carbonaceous matter, which formed the coal, has been sometimes entirely removed, and even channels cut in the supporting *Stigmaria* beds, by the water which bore, and allowed the deposit of, the sand or silt now forming sandstones or arenaceous shales, covering the eroded and non-eroded parts: such erosion having taken place when the coaly matter was unconsolidated.

An excellent example of the erosion of coal into channels, like those amid some peat bogs, occurs in the Forest of Dean, where it is known as "the Horse." This "Horse," with its tributaries, named "Lows," will be found well described by the late distinguished colliery viewer, Mr. John Buddle, in the Transactions of the Geological Society of London, new series, vol. vi. 213. The Memoir is accompanied by an illustrative plan and section.

‡ The intermingling of the *Stigmaria* and coal beds or seams has often led to the supposition, especially when a *Stigmaria* bed beneath any coal worked was rarely

"fire-clays" contain the *Stigmaria* roots, properly permeating their ancient soil, there is usually a little difficulty in practically tracing their crop, but when the mineral matter of these beds takes the more ordinary form of a sandstone or arenaceous shale, the case is different. Then an examination of the mode of occurrence of the *Stigmaria* roots themselves is essential, especially when the lithological character of the bed may be liable to change, and in some coal districts we have been enabled to trace the same *Stigmaria* bed from the ordinary condition of a fire-clay to a rock in which the arenaceous matter greatly prevailed.*

Note on the Mode of working the Coal and Ironstone of South Staffordshire. By Warington W. Smyth, M.A., Professor of Mining and Mineralogy to the Museum of Practical Geology.

A brief sketch of the modes of working the beds of coal and ironstone in South Staffordshire is appended, with a view of recording generally the practical methods, adopted at the present time, for the extraction of those rich stores of mineral wealth of which the geological relations have been described in the preceding pages.

The acknowledged requisite for the most advantageous method of working, viz. the combination of the cheapest mode of extracting the greatest possible quantity of mineral, with the safety and comfort of the men, has in this district been greatly modified by the circumstances of position, and an adherence to long established customs. In a few rare instances only have any attempts been made to substitute a new system for the old routine, and to such it will be needful to advert after we have viewed the principal features of the practice almost universally followed.

In the first place, the division of the ground into separate works is guided by the faults which in so many instances constitute natural boundaries and by the depth from the surface, of the deposits proposed to be worked; and an observer, conversant with districts of coal where extensive unbroken areas are worked at great depths by few shafts, cannot fail to be struck with the appearance of the South Staffordshire field, dotted over as it is with innumerable shafts, and deformed by the large waste heaps of slate and slack which so frequently surround them. The cause of this, lying in the subdivision into small areas, and the comparative shallowness of the workings, and conducive no doubt to simplicity in all the internal arrangements, afford such facilities for securing the desiderata above alluded to, that it must be a matter of surprise to find that certain ancient incomplete usages should so long have held their ground.

The shafts by which access to the coal and ironstone measures is to be obtained, are sunk two together, at a distance of six or eight yards asunder, and with a diameter of six or eight feet. Each shaft being

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touched or examined, that these beds occurred quite as much above coal beds as beneath them, the roof of a given working being formed of a *Stigmaria* bed. Illustrative instances of the interstratification of *Stigmaria* with coal beds in South Wales, will be found in the Memoirs of the Geological Society, vol. i. p. 153.

* The consolidation of *Stigmaria* beds is occasionally very considerable, even approaching that of quartz rock. Good examples of *Stigmaria* beds thus consolidated may be seen on the coast (at Lilliput) near Swansea, where from the infiltration of silica, two beds, each supporting small beds of coal, and penetrated by *Stigmaria* roots and rootlets in their relative places of growth, have become hard quartz rocks.

intended for a single rope or "band," is surmounted by a head-frame carrying one broad pulley of cast-iron, and the whimsey engine is so placed as to be able to serve two shafts at once, raising a loaded "skip" in the one, and lowering an empty one in the other, at the same time. The difficulties of sinking, as regards watery strata, being inconsiderable, except in some few cases, the ingenious and expensive application of wooden or iron tubbing, practised so frequently in the Belgian, and in our northern coal-fields, is almost unknown; and the shafts are lined with brick-work, unless when they pass through strata sufficiently strong to stand permanently without support. The area of the shafts is free from any obstruction, no "guides" being employed to regulate the passage of the "skips" or frames upon which the coal is piled in large masses surrounded by loose "rings," of sheet iron, and from which less than might be expected falls off during the ascent. Ponderous flat chains of three links, alternately short and long, with slips of wood inserted through the long links, are most frequently used for the drawing, and for shafts of moderate depth are very effective and safe.

Taken apart from minor details, the modes of working the mines are two in number, the first applied to the important beds called the "thick coal," and the "new mine;" and the second, termed "long work," (not, like the former, peculiar to the district,) employed in the other coal seams of from two to five feet in thickness, and in the ironstone measures.

The workings of the ten-yard coal are divided into compartments termed *sides of work*, which are separated from one another by "ribs," or walls of coal, from eight to ten yards thick, and of which no more are kept open at once than can be maintained in activity.

From the main roads, termed *gate-roads*, each *side of work*, unless commenced near the outer boundary, is accessible only through a narrow opening, cut, like the gate-road itself, in the lower part of the seam. "Stalls" are then driven out in the coal, each of them eight or ten yards wide, and are crossed again by similar galleries, leaving between them pillars of eight or ten yards square, but varied of course in dimension, according to local circumstances. For additional security during the working, small pillars of three or four yards square at the base, termed *men of war*, are spared out of the solid coal, wherever it is deemed necessary, to be rapidly prostrated and carried off, when the stall is fully opened. But the driving of the stalls themselves is a work involving no little waste of coal and insecurity to the colliers; the mass of coal of eight yards wide having to be undercut, or *holed* about a couple of yards in, a large amount of coal is cut up into slack by the "pike," or collier's pick, and the men are exposed to continual risk from falls of coal. As the various portions of the seam are successively "cut" at the side of the stall, and brought down, the colliers have to mount on heaps of slack or light wooden stages, and are necessarily exposed to still greater danger.

There is, in fact, perhaps scarcely any situation more suggestive of feelings of awe, than a side of work in the "thick seam," when a large fall of coal is brought down from the dusky heights of that lofty chamber; the thunder of the falling masses which seem to shake the solid earth and fill the air with a thick cloud of dust, contrasting fearfully with the dead silence which ensues, and which the hardy colliers scarce break by a whisper, whilst in suspense they listen for the slightest crack which might portend a farther fall.

When a compartment has thus been cleared and the large pillars sometimes a little thinned, the "slack" or small coal and dust is left in

heaps, and to guard againt the spontaneous combustion, apt to ensue from the decomposition of small particles of pyrites, a dam is placed in the "bolt hole," and this portion cut off from all communication with the rest of the workings.

The second mode of getting, by what is called long work, need not be described at length, being very similar to that practised in Shropshire, Derbyshire, and other districts; it is, as elsewhere, variable according to the condition of the roof, &c., the road-ways being sometimes driven out through the "whole coal," which is then worked back towards the shafts, in other cases the roads being maintained through the "gob" or waste from which the coal has been removed, as the extraction proceeds from the shafts towards the limits of the field.

Very important, however, in an economical point of view, both to the lord of the soil, and to the lessee, as well as to the interest of humanity, is the success which has attended the efforts of certain coalowners to get the ten-yard coal on the principles of "long work," as exemplified in the pits of the Messrs. Foster, of Mr. Gibbons, and at Congreaves. We have seen that by the usual method, what with the ribs and pillars left untouched and the quantity of coal cut up into slack, a vast amount of useful fuel—of what in fact in a very few years *must* become of much higher value, is utterly lost to the nation.

It is not too much to assert, that from one-third to one-half of the coal is thus left useless, (some little only of the ribs and pillars being afterwards recoverable in a damaged condition,) an amount of squandered natural advantages almost without a parallel.

By the common plan it is considered that 16,000 tons of coal obtained from an acre of ground represents a very fair produce, and no doubt a very much lower number is often obtained. At Messrs. Foster's, the coal is worked in two divisions, the upper half first, by long work, and then some months afterwards, when the "shut" or roof has fully subsided, the lower half is worked by the same method, and a total amount of from 26,000 to 31,000 tons of coal to the acre is procurable, and it need only be added to the conclusions suggested by a comparison of these numbers, that, under this newly applied system, there has been enjoyed a comparative immunity from those frequent and frightful accidents which have gained the workings of the Thick coal a most unenviable notoriety.

In conclusion, the ventilation of these works requires a short notice, from the fact, that although the coal is not highly charged with fire-damp, very serious accidents have happened from explosions, and the every-day state of some of the pits cannot be regarded without dread. The establishment of a current of air is left much to accident; and the causes disposing the air to travel down one shaft and up the other are so easily disturbed by a change of wind, or other trivial cause, that a stagnation is frequently produced, or the pits are said to *fight*, and during the contest, if nothing more serious occurs, the colliers are obliged to "play" or absent themselves.

"Air-heads," of not more than 9 or 10 feet sectional area, are driven in the coal parallel with the gate-roads, and communicate with the "sides of work;" but unless, according to the suggestion of Ryan, they are driven in the upper part of the seam, there must frequently accumulate in those high working stalls a magazine of explosive gas ready to fire on the first opportunity, so easily afforded by a fall of coal, a change in the barometer, or the imprudence of a workman.

It need scarcely be observed how greatly the danger is augmented, when the "air heads" are not brought up simultaneously with the main workings, yet under the "butty" or "chartermaster" system, it is too

common to find those important works omitted for long distances, and the men working in a confined space charged with foul gases and fire-damp almost to the explosive point.

A great deal might be said on the details of this and the previous subjects, but I would hope that these short notes may only serve as a record of rude practices soon to be improved, and must refer the reader, desirous of further information on these heads, to the evidence before the Committee of the House of Commons in 1835, of the House of Lords in 1849, to the report of Mr. J. Kenyon Blackwell, to Smith's Miner's Guide, published in 1836, and to Mr. Gibbons's pamphlet on his method of ventilation. No one, I believe, even practically unacquainted with the subject, will rise from the perusal of those statements without feeling that in the waste of a treasure of unique richness, and in the abandonment of an energetic and honest class of workmen to the dangers resulting from the absence of mental training, we have hitherto deserved as a nation but little credit for the stewardship of some of our finest coal-fields.

NOTE.

The following extracts from Plot's Natural History of Staffordshire, published in 1686, may serve to show the state of the South Staffordshire district, as regarded its coal and iron at that time. Speaking of the common coal then raised at Wednesbury, Dudley, and Sedgley, Dr. Plot says, "of which sort there is so great plenty in all "parts of the country, (especially about the three above mentioned places,) that most "commonly there are 12 or 14 *colery's* in work, and twice as many out of work, "within 10 miles round, some of which afford 2,000 tuns of coal yearly, others three, "four, or five thousand tuns. The upper or topmost beds above the ironstone lying "sometimes ten, eleven, or twelve yards thick. * * * * * Nor indeed "could the country well subsist without such vast supplies, the wood being most of it "spent upon the ironworks."

Alluding to the attempts which were made to smelt iron with coal or coke, he says, "The last effort that was made in this country for making iron with pit coal, was also "with raw coal, by one *Mr. Blewstone*, a high *German*, who built his furnace at "Wednesbury, so ingeniously contrived that only the flame of the *coal* should come to "the *oare*, with several other conveniences, that many were of opinion he would "succeed in it. But experience, that great baffler of speculation, showed it would not "be. The sulphureous vitriolic steams that issue from the pyrites, which frequently, "if not always, accompanies *pit coal*, ascending with the flame, and poysoning the *ore* "sufficiently to make it render much worse *iron*, than that made with *char-coal*, though "not perhaps so much worse, as the body of *coal* it-self would possibly doe."

The different kinds of iron made are mentioned under the heads of 1. Redshare; 2. Coldshare; 3. Blend metell; and tough iron, the last being the best, and chiefly made from ores obtained at Rushall. The ores were first calcined on the open ground, "with small charcoal, wood, or sea-cole." After this they were taken to the blast furnace, where they were smelted with charcoal, one basket of the latter being used to one basket of calcined ore. The iron run from the furnaces was then taken to the forges, which were of two kinds, one known as the Finery, the other as the Chafery, and made into bars. For cutting the iron into rods it was taken to Slitting mills, and there cut and rolled.

Speaking of the improvement then made in iron smelting, Dr. Plot remarks, "we "shall find it very great, if we look back upon the *methods* of our *ancestors*, who made "*iron* in *foot blasts*, or *bloomeries*, by mens treading the bellows, by which way they "they could make but one little lump or *bloom* of *iron* in a day, not 100 weight, leaving "as much *iron* in the *slag* as they get out. Whereas now they will make two or three "tuns of *cast iron* in 24 hours; leaving the *slag* so poore, that the founders cannot "melt them again to profit. Not to mention the vast advantage they have from the "new invention of *slitting mills*, for cutting these barrs into rodds, above what they "had antiently."

It would appear that the first successful smelting of iron ore by means of coal, then usually called pit or sea coal, was effected by Dud Dudley in the year 1619. Other unsuccessful attempts by Simon Sturtevant, John Rovenson, and others having been previously made.

Dud Dudley in his book Metallum Martis, 1665, says, that having been taken from Baliol College, Oxford, where he was then a student, in 1619, "to look and manage "3 iron works of my fathers, 1 furnace, and 2 forges, in the Chase of Pensnet, in "Worcester-shire, but Wood and Charcole, growing then scant, and Pit-coles in "great quantities abounding near the furnace, did induce me to alter my furnace, and "to attempt by my new invention, the making of iron with pit-cole, assuring myself "in my invention, the loss to me could not be greater then others, not so great, "although my success should prove fruitless; but I found such success at first tryal "animated me, for at my tryal or blast I made iron to profit with pit-cole, and found "*Facere est addere Inventioni.*" * * *

"After I had made a second blast and tryal the fesibility of making iron with pit-"cole and sea-cole I found by my new invention, the quality to be good and profitable, "but the quantity did not exceed above 3 tuns per week."

A patent for smelting iron ore by pit or sea coal was granted to Dud Dudley in 1619. In the year following his works were swept away by a great flood, known for long afterwards as the May-day flood.

We, however, find Dud Dudley stating that the works were repaired, and that he "made annually great store of iron, good and merchantable, and sold it to divers men, "yet living (1665) at twelve pounds per tun." Making "all sorts of cast iron wares, as "brewing-cysterns, pots, morters, and better and cheaper than any yet were made "in these nations with charcoles." Subsequently we find him smelting with pit-cole at Himley Furnace, Staffordshire, having been "ooted of his works and inventions "before-mentioned by the ironmasters and others wrongfully," and again at Hasco-Bridge in the parish of Sedgley, Staffordshire, making seven tons of iron per week—"the greatest quantity of pit-cole iron that ever yet was made in Great Britain.

Dud Dudley's works were riotously destroyed, and he himself by adhering to the royal cause became utterly ruined.

As respects the prices of the iron made by Dud Dudley, he states that "he did sell "pig or cast iron made with pit-cole at four pounds per tun, many tuns, in the twentieth "year of King James with good profit." He further says—"The author did sell bar "iron good and merchantable, at twelve pounds per tun and under, but since bar "iron hath been sold for the most part ever since at 15*l.*, 16*l.*, 17*l.* and 18*l.* per tun by "charcoal iron masters."—*Metallum Martis*, p. 32.

NOTE on the COAL RAISED and IRON MADE in 1858 in SOUTH STAFFORDSHIRE. By ROBERT HUNT, F.R.S., Keeper of Mining Records.

The quantity of Coal raised in South Staffordshire was 4,995,780 tons; the present value of which may be regarded as 1,248,945*l.* sterling.

The quantity of coal required for calcining and for smelting the iron ore is at the rate of about three tons of coal for one ton of iron, or about 1,793,427 tons were employed in 1858 for that purpose. This is exclusive of the coal required for the manufacture of bar iron, &c.

The quantity of ironstone raised from the South Staffordshire coal measures, was about 959,000 tons; the average production of iron from this ironstone ore being about 33 per cent.

In addition to this ore, the following and some other ironstones were consumed in South Staffordshire:—

	Tons.
From North Staffordshire:—	
Sent by railway, iron ore, *calcined*	76,367
„ „ „ „ uncalcined	15,797
Sent by canal „ „ *calcined*	135,861
„ „ „ „ uncalcined	79,327
From Lancashire and Cumberland, about	30,000
„ Forest of Dean, about	13,000
„ Northamptonshire and other places, about	50,000
	400,352

The quantity of pig iron made in South Staffordshire for the last three years has been as follows :—

1856.	1857.	1858.
Tons.	Tons.	Tons.
777,171	657,295	597,809

The number of furnaces built and in blast is given in the first table; the number of mills and forges in the second.

The Number of Iron Furnaces in Blast in South Staffordshire and Worcestershire, 147.

No.	Names of Works.	Owners.	Furnaces built.	Furnaces in blast.	Furnaces in blast in District.
1	Bentley Heath - -	Riley and Co. - -	3	0	
2	Birchills, New, *Walsall* -	Henry Smith - -	5*	3	
3	„ Old „ -	F. C. Perry - -	2	2	
4	Bloxwich, Green Lanes, *Walsall.*	T. and C. Highway -	2	2	
5	Bovereux, *Bilston* -	Wm. Baldwin and Co. -	2	1	
6	Brettell Lane „ -	Hall, Holcroft, and Pearson	2	2	
7	Broadwaters „ -	S. Groucutt and Sons -	3	3	
8	Brook „ -	G. H. and A. Hickman -	3	2	
9	Caponfield „ -	John Bagnall and Sons -	3	3	
10	Chillington - -	Chillington Iron Company	4†	3	
11	Coneygree, *Tipton* -	Lord Ward - -	3	2	
12	Corbyns Hall, - *Dudley*	Wm. Matthews and Co. -	4	3	
13	„ „ New „ -	B. Gibbons - -	4	2	
14	Coseley, *Bilston* - -	Jos. and Thomas Turley -	2	2	
15	Crook Hay - -	Geo. Thompson and Co. -	4	2	
16	Darlaston Green - -	Samuel Mills - -	3	3	
17	Deepfields, *Bilston* -	Benton and Pemberton -	3	1	
18	Dixon's Green, *Dudley* -	W. Haden - -	1	1	
19	Dudley Port - -	Hopkins and Son - -	2	2	
20	Dudley Wood - -	New British Iron Co. -	4	4	
21	Ettingshall, *Bilston* -	T. Banks and Son -	2	1	
22	Gold Hill, *West Bromwich*	John Bagnall and Sons -	3	3	
23	Hallfields - -	B. Gibbon, jun. - -	1	1	
24	Hatherton - -	Highway, Brothers -	2	2	
25	Herbert's Park, *Bilston* -	David Jones - -	1	1	
26	Horseley, *Tipton* - -	Colburn and Sons - -	4	3	
27	Ketley's, *Dudley* - -	B. Gibbons - -	3	3	
28	Lays, *Stourbridge* -	W. and G. Firmstone -	3	3	
29	Level, New, *Brierley Hill*	Lord Ward - -	3	3	
30	„ Old „ -	Hall, Holcroft, and Pearson	2	1	
31	Millfield, *Bilston* - -	B. Gibbon, jun., and Co. -	3	3	
32	Moseley Hall, *Wolverhampton.*	Chillington Company -	3	3	
33	Netherton - -	N. Hingley and Sons -	2	2	
34	„ - - -	M. and W. Grazebrook -	2‡	2	
	Carried forward -	- - - -	93	74	

* 4 furnaces were in blast for a short time. The average of the year was 3 furnaces.

† During a portion of the year the Chillington Company had 4 furnaces in blast.

‡ These furnaces are entirely cold blast.

Number of Iron Furnaces in Blast, &c.—*continued.*

No.	Names of Works.	Owners.	Furnaces built.	Furnaces in blast.	Furnaces in blast in District.
	Brought forward -	- - - -	93	74	
35	New Furnaces, *Bilston* -	S. H. Blackwell and Co. -	5	4	
36	Oak Farm, *Dudley* -	Oakfarm Furnace Company	2	2	
37	Oldbury - - -	William Bennit - -	4	4	
38	Old Hill, *Dudley* - -	T. and J. Badger - -	2	1	
39	Old Park - -	Lloyds, Foster, and Co. -	3	3	
40	Osier Bed - -	W. H. Sparrow and Co. -	3	3	
41	Park Head - -	Evers and Martin - -	2	2	
42	Parkfield - -	Parkfield Iron Company* -	5	4	
43	Park Lane, *Tipton* -	Thomas Morris - -	2	1	
44	Pelsall - - -	Davies and Bloomer -	2	2	
45	Priestfield - -	W. M. Ward and Sons -	3	3	
46	Priors Field - -	H. B. Whitehouse - -	3†	3	
47	Rough Hay, *Darlaston* -	Addenbroke, Smith, and Pidcock.	2	2	
48	Russell's Hall, *Dudley* -	S. H. Blackwell and Co. -	5	4¾	
49	Shut End, *Stourbridge* -	John Bradley and Co. -	4	3	
50	Spring Vale, *Bilston* -	Jones and Murcott -	3	2¼	
51	Stone Field - -	G. H. and A. Hickman -	1	1	
52	Stour Valley - -	B. Richards - -	2	0	
53	Stow Heath - -	W. H. Sparrow and Co. -	5	4	
54	Tipton - - -	E. Creswell and Sons -	2	2	
55	Tipton Green - -	Gibbons and Robert -	4	4	
56	Toll End, *Tipton* -	Toll End Company -	2	0	
57	Union - - - -	Phillip Williams and Company.	3	3	
58	Wednesbury Oak -	Ditto - - -	3	2	
59	Willinghall - -	Fletcher, Solly, and Urwick	3	2	
60	Wellingsworth - -	Haines and Company -	3	3	
61	Windmill End - -	Woodall and Smith -	3	2	
62	Withymoor - -	W. Dawes - -	2	2	
63	Wolverhampton - -	Edward Poole and Co. -	3	2	
64	Woodside - -	Cochrane and Company -	3	2	
		Total - -	182	147	

Mills and Forges in South Staffordshire District, with the Number of Puddling Furnaces.

1	Jno. Bradley and Co. -	Stourbridge Works	Stourbridge -	23
2	Ditto - - -	Brierley Works -	Kingswinford -	38
3	Ditto - - -	Shut End - -	Ditto - -	34 = 95
4	Jno. Bagnall and Sons -	Imperial Works -	Wednesbury -	26
5	Ditto - - -	Lee Brook - -	Ditto - -	28
6	Ditto - - -	Gold's Hill - -	Tipton - -	31 = 85
7	G. B. Thorneycroft and Co.	Shrubbery Works	Wolverhampton	40
8	Ditto - - -	Swan Garden -	Ditto - -	30 = 70
9	Barrows and Hall - -	Bloomfield Works	Tipton - -	56
10	Ditto - - -	Factory Works -	Ditto - -	22
11	Ditto - - -	Tipton Green -	Ditto - -	11 = 89
12	Chillington Iron Company	Chillington Works	Wolverhampton	56
	Carried forward -	- - - -	- - -	339

* 3 furnaces in blast for 3 months, and 4 for 9 months.

† 2 only in blast one half the year.

Mills and Forges in South Staffordshire, &c.—*continued.*

	Brought forward -	- - - - -	- - -		339
13	Chillington Iron Company	Lee Brook - -	Wednesbury -	23	
14	Ditto - - -	Bradley - -	Bilston - -	14	
15	Ditto - - -	Capponfield - -	Ditto - -	16 =	109
16	Walter Williams - -	Albion Works -	West Bromwich	50	
17	Ditto - - -	Great Bridge -	Tipton - -	12 =	62
18	British Iron Company -	Corngreaves -	Dudley - -	56	
19	Ditto - - -	Brierley Hill -	Ditto - -	18 =	74
20	Jones and Murcott -	Spring Vale - -	Bilston - -		68
21	John Dawes and Son -	Bromford Works -	Oldbury - -		51
22	W. and J. Sparrow and Co.	Osier Bed - -	Wolverhampton	26	
23	Ditto - - -	Bilston Works -	Bilston - -	32 =	58
24	Phillip Williams and Sons	Wednesbury Oak -	Tipton - -		32
25	J. Walker and Co. -	Patent Shaft Company.	Wednesbury -		48
26	Lord Ward - -	Round Oak - -	Brierley Hills -		45
27	Corbyn's Hall Iron Company	Corbyn's Hall Works.	Kingswinford -		40
28	Solly Brothers - -	Lee Brook - -	Wednesbury -	25	
29	Ditto - - -	Great Bridge -	Ditto - -	18 =	43
30	W. Riley and Son - -	Highfield Works -	Bilston - -		26
31	Rose, Higgins, and Rose -	Bradley Works -	Ditto - -		33
32	Browning and Jackson -	Deepfields Works -	Ditto - -		10
33	Brown and Frere - -	The Lays - -	Dudley - -	28	
34	Ditto - - -	The New Lays -	Ditto - -	10 =	38
35	J. and E. Walker - -	Old Church and Gospel Oak.	Tipton - -		27
36	Atlas Iron Company -	Atlas Works -	West Bromwich		13
37	Sir S. Glyn, Bart. - -	Oak Farm - -	Kingswinford -		38
38	R. Jeffries - -	Hart's Hill Works	Brierley Hill -		30
39	E. Cresswell and Sons -	Tipton Works -	Tipton - -	20	
40	Ditto - - -	Moxley Works -	Wednesbury -	10 =	30
41	Thomas Wells - -	Moxley - -	Ditto - -		25
42	Hickman and Co. - -	Groveland Works -	Tipton - -	18	
43	Ditto - - -	Stonefield - -	Bilston - -	10 =	28
44	Davis and Bloomer -	Pelsall Works -	Walsall - -	12	
45	Ditto - - -	Gold's Hill - -	Tipton - -	11	
46	Ditto - - -	Greet's Green -	West Bromwich	20 =	43
47	David Jones - -	Herbert's Park -	Darlaston - -	15	
48	Ditto - - -	Bilston Brook -	Bilston - -	8 =	23
49	Plant and Fisher - -	Dudley Port Works	Tipton - -		20
50	E. Page and Sons - -	Roway Works -	West Bromwich		23
51	S. Mills - - -	The Green Ironworks.	Darlaston - -		22
52	Lee and Bolton - -	The Hyde Works -	Stourbridge -		21
53	S. Groucutt and Sons -	Bankfield Works -	Bilston - -		20
54	Fletcher, Rose, and Co. -	Albert Works -	Moxley - -		21
55	Daniel Rose - -	Bull's Bridge -	Ditto - -		10
56	Wm. Rose - -	Batman's Hill -	Bilston - -		10
57	Wright and North -	Monmore Green -	Wolverhampton		11
58	Isaac Jenks - -	Minerva Works -	Ditto - -		13
59	Hall, Holcroft, and Pearson	The Level -	Brierley Hill -		17
60	Budd and Co. - -	Tividale Ironworks	Tipton - -	9	
61	Ditto - - -	Brockmoor Works	Dudley - -	6	15
62	Thomas Silvester and Son	Spon Lane - -	West Bromwich		12
63	Beasley and Farmer -	District Forge -	Smethwick -		20
64	Millington and Co. -	Summer Hill -	Tipton - -		15
65	F. Giles and Co. - -	Dudley Port Works	Ditto - -		14
66	Badger and Co. - -	Ditto - -	Ditto - -		14
67	Evers and Sons - -	Cradley Works -	Dudley - -		17
68	N. Hingley and Sons -	Netherton Works -	Ditto - -		15
69	John Wheeley and Co. -	Brettel Lane - -	Stourbridge -		16
70	Corkley Iron Company -	Corkley - -	Kidderminster -		12
	Carried forward -	- - - - -	- - -		1,671

Mills and Forges in South Staffordshire, &c.—*continued.*

	Brought forward -	- - - -	- - -	1,671
71	Lloyds, Foster and Co. -	Old Park - -	Wednesbury -	12
72	Ditto - - -	King's Hill - -	Ditto - -	6= 18
73	Deaken and Dodd -	Monmer Lane Iron-works.	Willenhall -	11
74	Eagle Coal and Iron Company.	Greet's Green -	West Bromwich	14
75	J. Whitehouse - -	Ridge Acre - -	Ditto - -	19
76	Crange and Holden -	Great Bridge -	Ditto - -	10
77	John Stones and Son -	The Grove - -	Smethwick -	10
78	Granager and Powers -	- - - -	Ditto - -	10
79	Keep and Watkin - -	Swin Works -	Stourbridge -	13
80	Geo. Thompson and Co. -	Crook Hay Works	West Bromwich	18
81	Gilpin and Sons - -	Wedge's Mills -	Walsall - -	6
82	J. Marshall - -	Monway Works -	Wednesbury -	6
83	Johnson and Co. - -	Church Lane -	West Bromwich	7
84	Bissell, Kay, and Bissell -	Hill Top - -	Ditto - -	10
85	Hipkins and Co. - -	Great Bridge -	Ditto - -	5
86	J. Gregory - -	Spon Lane - -	Ditto - -	6
87	Hartland and Co. - -	Smethwick - -	Ditto - -	8
88	Wm. Marshall - -	- - - -	Ditto - -	3
89	J. Hodgetts - -	- - - -	Ditto - -	3
90	Wm. Morris - -	- - - -	Tipton - -	4
91	J. Haines and Co. - -	Sheep Wash - -	Ditto - -	10
92	Hunt and Sons - -	Brade's Works -	Oldbury - -	8
93	E. B. Whitehead - -	- - - -	Tipton - -	9
94	Wm. Baldwin and Co. -	Bovereux Works -	Bilston - -	6
95	Wm. Banks - -	Ettingshall Works	Ditto - -	11
96	Thompson and Burford -	Bradley Hall Works	Ditto - -	10
97	Hampton and Brereton -	Pot House Bridge Works.	Ditto - -	7
98	Baldwin and Co. - -	Horseley Fields Works.	Wolverhampton	3
99	Whittington Company -	Whittington Works	Stourbridge -	7
100	Banks and Morgan -	Broadwaters - -	Kidderminster -	5
101	Baldwin Brothers -	Wildon Works -	Ditto - -	5
102	Edmund Page - -	- - - -	Smethwick -	12
	Total - -	- - - -	- - -	1,945

The number of collieries enumerated in the Mineral Statistics for 1858 is 415 in this coal-field. Each of these collieries will have at least two shafts, and many of them more.

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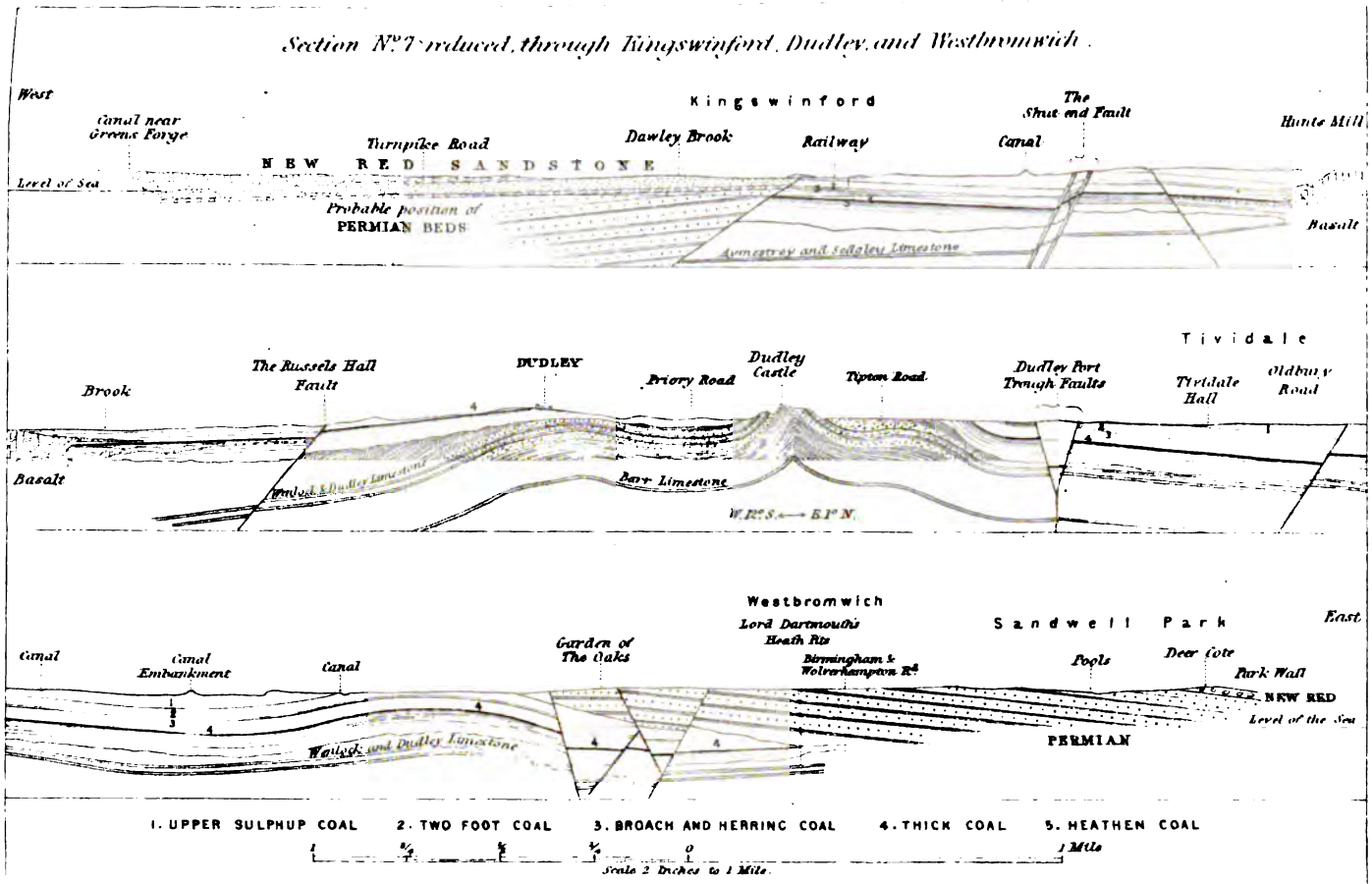

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61 SE. Part of Shropshire.
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73 SE. Part of Shropshire and Staffordshire.
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74 NW. Part of Denbigh, Merioneth, and Caernarvon.
74 NE. Part of Denbigh, Flint, Shropshire, and Merioneth.
74 SW. Part of Montgomery, Denbigh, and Merioneth.
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75 NW. Part of Caernarvon.
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75 SW. Part of Caernarvon.
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76 N. Part of Caernarvon.
76 S. Part of Caernarvon.
77 N. Part of Holyhead Island.
78 NW. N. part of Anglesea, and part of Holyhead Island.
78 NE. E. corner of Anglesea.
78 WS. S. of Holyhead Island and of Anglesea, with part of Caernarvonshire.
78 SE. Part of Anglesea on Menai Straits, NE. of Caernarvonshire, and W. of Denbighshire.
79 NW. Part of Flint, Denbigh, and Caernarvon.
79 NE. Part of Flint, Cheshire, and Lancashire.
79 SW. Part of Flint, Caernarvon, and Denbighshire.
79 SE. Part of Cheshire, Flint, and Denbigh.
80 SE. Northwich.
80 SW. Chester, part of Cheshire.
81 NE. Part of Derbyshire and of W. R. Yorkshire.
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